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THE CATARACT DAM, SYDNEY, NEW SOUTH WALES.

Discharge of a Large Volume of Flood Water Over the Dam During Construction.

By L. A. B. Wade,* M. Inst. C. E.

The water supply of the city of Sydney is derived from the Nepean and Cataract rivers. The catchment area of 354 square miles, with water from the rivers mentioned is conveyed to Prospect by a system of canals and tunnels, having a daily capacity of only 180,000,000 U. S. gals., the storm flow of the rivers cannot be fully availed of.

In order to increase the storage a masonry and concrete dam is being erected on the Cataract River, which will impound 25,700,000,000 U. S. gals. from a portion (50 square miles) of the catchment above mentioned. The dam is straight on top, with a height to full supply level of 147 ft., and a total height of 154 ft. above the river bed. The flood waters on completion will be taken over a by-wash [spillway] at one side, having a total length of 730 ft. The surface area of the impounded water at full supply level will be 2,145 acres.

The main bulk of the dam consists of cyclopean rubble masonry formed of blocks of sandstone weighing from 2 to 4½ long tons set in cement mortar and packed in with concrete, in which basaltic stone is used. The sandstone blocks are roughly hewn to rectangular form, and the proportion of blocks to concrete and mortar is approximately as 65 to 35. The up-stream face of the dam consists of basaltic concrete blocks, 5 × 2½ × 2 ft., molded, set in cement and backed by an average of 3 ft. of basaltic concrete, while the down-stream face is formed of 6 ft. of basaltic concrete molded in place.

The foundations of the dam have been carried to a depth of 40 ft. below the bed of the river in solid sandstone rock. Two 48-in. pipes, with valves, communicating with outlet wells and

CATARACT DAM UNDER CONSTRUCTION; SYDNEY WATER-WORKS, NEW SOUTH WALES.

the good rainfall, which is characteristic of the coastal districts of New South Wales, is ample for the requirements of the city, even supposing enormous expansion; but the existing storage at Prospect (only 6,600,000,000 U. S. gals., by gravitation) is quite inadequate; and, further, as the

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sluice valves in the up-stream face of the work, will form the permanent outlet; but two additional 48-in. pipes (making four in all) are provided to pass the river flow during construction.

The valve house on the down-stream side of the dam is roofed with reinforced concrete to provide against damage by water topping the work during construction, and the contracts provide that the valves shall be left open till the lowest portion of the wall reaches a level of approximately 80 ft. above the river bed.

It is in connection with this provision that the remarkable coincidence which resulted in the discharge of an enormous volume of water over the dam, which is shown by the view on page 581, occurred. An exceedingly dry period of 15 months duration, prior to Aug. 30, resulted in the depletion of the city supply. Indeed, so small was the flow of the river during that period that one 48-in. pipe more than sufficed to carry it off. An arrangement was accordingly made with the contractors that the valves should be closed, and water, if any, impounded on Aug. 30. On Aug. 28 work was being concentrated upon the lowest portion of the wall, then 76 ft. above the river bed, the gap being about 65 ft. in width. Aug. 29 was showery. On Aug. 30, at 5 p. m., the valves were closed. At 6 p. m. the same day, after 15 months' dry weather, heavy rain (amounting to 10 ins.) fell on the catchment, and by 6 a. m. on the following day, the 31st, the water was flowing over the dam to a depth of 16 ft. in the gap, the lake above the dam holding at that time approximately 2,400,000,000 U. S. gals. The engineers opened one of the 48-in. valves to reduce the surcharge; but it was not considered advisable to open the other three values, on account of the vibration likely to result from the high velocity, as the fixing of the valves was not quite completed. Rain ceased on Aug. 31, and on Sept. 3 the discharge from the open valve and over the wall had reduced the level of the lake to the level of the top of the wall (76 ft), when the valve was partially closed and work resumed.

No damage was done to the structure by the overtopping, though one or two blocks of sandstone not yet set were carried from the top of the wall and struck the roof of the valve house in falling. The cut showing the flow through the gap in the dam is from a photograph taken by Mr. E. M. de Burgh, M. Inst. C. E., on Aug. 31, when about 10 ft. of water was flowing over the wall.

The dam when completed will be the largest in Australia, containing 144,670 cu. yds. of concrete and masonry, and is estimated to cost, including clearing of reservoir area, £325,500 ($1,585,000). A very modern plant, consisting of electric-driven Lidgerwood cableways and electric cranes, has been used in its construction, and the concrete is mixed by electric-driven machines. The writer is responsible for the design and carrying out of the structure, assisted by Mr. E. M. de Burgh, M. Inst. C. E., of the same department, who has principal charge of the work. Mr. J. Symonds is Resident Engineer. Messrs. Lane & Peters are the contractors.

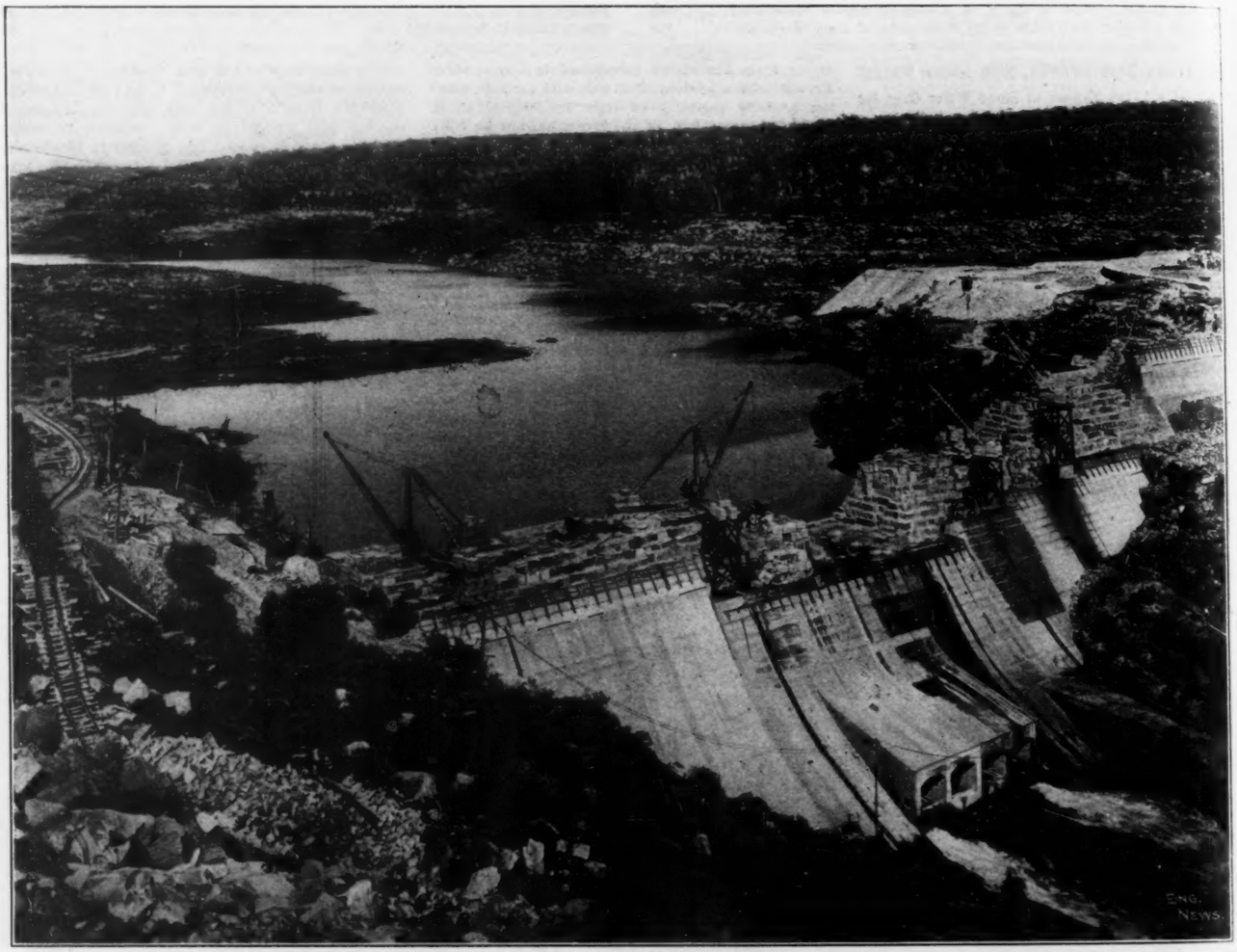

FIG. 2. CATARACT DAM, SYDNEY WATER-WORKS, NEW SOUTH WALES; DAM FROM BELOW, SHORTLY BEFORE BEING OVERTOPPED DURING CONSTRUCTION.

TYPHOID FEVER IN BOTH INDIANA AND Michigan was prevalent to an unusual extent in October, according to reports made to the State Boards of Health of those States. In Indiana, 1,732 cases and 150 deaths were reported from 73 out of 92 counties in the State. In Michigan, 156 deaths are reported.

ON THE ART OF CUTTING METALS.*

By Fred W. Taylor,† President M. Am. Soc. C. E.

The experiments described in this paper were undertaken to obtain a part of the information necessary to establish in a machine shop, a system of management the central idea of which is:

(A) To give each workman each day in advance a definite task, with detailed written instructions, and an exact time allowance for each element of the work. (B) To pay extraordinarily high wages to those who perform their tasks in the allotted time, and ordinary wages to those who take more than their time allowance.

There are three questions which must be answered each day in every machine shop by every machinist who is running a metal-cutting machine, such as a lathe, planer, drill press, milling machine, etc., namely:

(a) WHAT TOOL SHALL I USE?
(b) WHAT CUTTING SPEED SHALL I USE?
(c) WHAT FEED SHALL I USE?

Our investigations, which were started 26 years ago with the definite purpose of finding the true answer to these questions under all the varying conditions of machine shop practice have been carried on up to the present time with this as the main object still in view.

The writer will confine himself almost exclusively to an attempted solution of this problem as it affects "roughing work"; i. e., the preparation of the forgings or castings for the final finishing cut, which is taken only in those cases where great accuracy or high finish is called for. Fine finishing cuts will not be dealt with. The principal object will be to describe the fundamental laws and principles which will enable us to do "roughing work" in the shortest time, whether the cuts are light or heavy, whether the work is rigid or elastic, and whether the machine tools are light and of small driving power or heavy and rigid with ample power. In other words, our problem is to take the

*Presidential address at the New York meeting of The American Society of Mechanical Engineers.

†Construction Engineer, Chestnut Hill, Philadelphia, Pa.

work and machines as we find them in a machine shop, and by properly changing the countershaft speeds, equipping the shop with tools of the best quality and shapes, and then making a slide rule for each machine to enable an intelligent mechanic with the aid of these rules to tell each workman how to do each piece of work in the quickest time.

FIG. 3. CATARACT DAM OVERTOPPED BY FLOOD DURING CONSTRUCTION.
(View taken Aug. 31, 1906. About 10 ft. of water over the unfinished work; the depth was 16 ft. at one time.)

It is to be distinctly understood that this is not a vague, Utopian result, to be hoped for in the future, but that it is an accomplished fact, and has been the daily practice in our machine shops for several years; and that the three great questions as to shape of tools, speed, and feed, previously referred to, are daily answered for all of the men in each shop far better by our one trained mechanic with the aid of his slide rule than they were formerly by the many machinists, each one of whom ran his own machine, etc., to suit his foreman or himself.

It may seem strange to say that a slide rule enables a good mechanic to double the output of a machine which has been run, for example, for ten years by a first-class machinist having exceptional knowledge of and experience with his machine, and who has been using his best judgment. Yet, our observation shows that, on the average, this understates the fact. To make the reason for this more clear it should be understood that the man with the aid of his slide rule is called upon to determine the effect which each of the twelve elements or variables given below has upon the choice of cutting speed and feed; and it will be evident that the mechanic, expert, or mathematician does not live who, without the aid of a slide rule or its equivalent, can hold in his head these twelve variables and measure their joint effect upon the problem.

The twelve elements or variables are as follows:

a the quality of the metal which is to be cut;
b the diameter of the work;
c the depth of the cut;
d the thickness of the shaving;
e the elasticity of the work and of the tool;
f the shape or contour of the cutting edge of the tool, together with its clearance and lip angles;
g the chemical composition of the steel from which the tool is made, and the heat treatment of the tool;
h whether a copious stream of water, or other cooling medium, is used on the tool;
j the duration of the cut; i. e., the time which a tool must last under pressure of the shaving without being reground;
k the pressure of the chip or shaving upon the tool;
l the changes of speed and feed possible in the lathe;
m the pulling and feeding power of the lathe.

Broadly speaking, the problem of studying the effect of each of these variables upon the cutting speed and of making this study practically useful, may be divided into four sections as follows:

(A) The determination by a series of experiments of the important facts or laws connected with the art of cutting metals. (B) The finding of mathematical expressions for these laws which are so simple as to be suited to daily use. (C) The investigation of the limitations and possibilities of metal cutting machines. (D) The development of an instrument (a slide rule) which embodies, on the one hand, the laws of cutting metals, and on the other, the possibilities and limitations of the particular lathe or planer, etc., to which it applies and which can be used by a machinist without mathematical training to quickly indicate in each case the speed and feed which will do the work quickest and best.

In the fall of 1880, the machinists in the small machine shop of the Midvale Steel Co., Philadelphia, most of whom were working on piece-work in machining locomotive tires, car axles, and miscellaneous forgings, had combined to do only a certain number of pieces per day on each type of work. The writer, who was the newly appointed foreman of the shop, realized that it was possible for the men to do in all cases much more work per day than they were accomplishing. He found, however, that his efforts to get the men to increase their output were blocked by the fact that his knowledge of just what combination of depth of cut, feed, and cutting speed would in each case do the work in the shortest time, was much less accurate than that of the machinists who were combined against him. His conviction that the men were not doing half as much as they should do, however, was so strong that he obtained the permission of the management to make a series of experiments to investigate the laws of cutting metals with a view to obtaining a knowledge at least equal to that of the combined machinists who were under him. He expected that these experiments would last not longer than six months. With the exception of a few comparatively short periods, however, these experiments have continued until the present time, through a term of about 26 years.

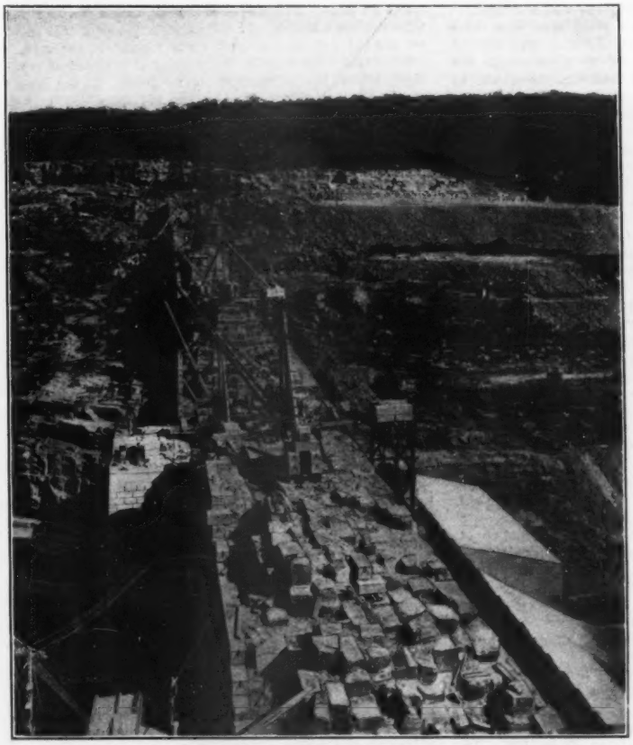

FIG. 4. TOP VIEW OF CATARACT DAM WHILE UNDER CONSTRUCTION.

The writer wishes to call attention to the fact that in these first experiments he was far more fortunate than almost all of the experimenters who have investigated the subject since then, in having at his disposal a comparatively large mass of uniform metal to work upon, and a comparatively large and powerful machine to work with, a 66-in. diameter boring mill and large locomotive tires made of hard tire steel of uniform quality having been used. He was also especially fortunate in having over him as president of the company, Mr. William Sellers, who, as is well known, was one of the most patient and broad-minded experimenters of his day. Mr. Sellers, in spite of the protests which were made against the continuation of this work, allowed the experiments to proceed; even, at first, at a very considerable inconvenience and loss to the shop. The extent of this inconvenience will be appreciated when it is understood that we were using a 66-in. diameter vertical boring mill, belt-driven by the usual cone pulleys, and that in order to regulate the exact cutting speed of the tool, it was necessary to slow down the speed of the engine that drove all of the shafting in the shop, a special adjustable engine governor having been bought for this purpose. For over two years the whole shop was inconvenienced in this way, by having the speed of its main line of shafting greatly varied, not only from day to day but from hour to hour. Before the two years had elapsed, however, the writer had obtained such valuable and unexpected results from the experiments as to much more than justify all of the annoyance and expenditure, and soon after that he readily obtained permission to employ a young technical graduate to devote his whole time to the continuation of this work.

Mr. G. M. Sinclair, a graduate of Stevens Institute of Technology, devoted his entire time to this work from 1884 to 1887, when he left the employ of the company. Mr. H. L. Gantt, also a graduate of Stevens Institute, succeeded Mr. Sinclair in July, 1887, and has been interested with us in carrying on these experiments throughout their whole period. In 1898 Mr. Maunsel White, of Bethlehem, another graduate of Stevens Institute, joined us and has been actively interested in our work up to this time. Mr. Carl G. Barth, a graduate of The Technical School of Horten, Norway, joined us in 1899, and is still actively working on our investigations. During these years we have consulted so freely together in all matters relating to these experiments that with few exceptions hardly a step has been taken which can be said to have originated with any one man. Therefore, whatever credit or blame may come to this work should be impartially divided among us. In writing this paper, then, no effort will be made to discriminate, as to the results which have been obtained in our investigations, between the work of one man and another.

Mr. White is undoubtedly a much more accomplished metallurgist than any of the rest of us; Mr. Gantt is a better all-round manager, and the writer of this paper has perhaps the faculty of holding on tighter with his teeth than any of the others. It should be said, however, that Mr. Barth, who is a very much better mathematician than any of the rest of us, has devoted a large part of his time during the last years of these experiments to carrying on the mathematical work along the lines laid out, and that without his special ability and untiring energy our progress would have been much slower, indeed it is doubtful whether we should have ever reached the present solution of the problem without his aid.

In addition to the five men who have mainly directed and carried on this work, the writer wishes to acknowl-

edge the most loyal and efficient aid and cooperation of many others who have assisted in the actual running of the machines and in recording or tabulating the data. Among these, he would particularly mention Mr. Dwight V. Merrick, Mr. D. C. Fenner, Mr. James Kellogg, Mr. Sidney Newbold, Mr. Joseph Welden, Mr. N. W. Wickersham, Mr. Edward Kneisley, and Mr. Leonard G. Backstrom.

Our experiments were continued in the works of the Midvale Steel Co. until 1889, when the writer left their employ. Since then, these investigations have been carried on in various shops and at the expense of different companies. Among these, we would especially acknowledge our indebtedness to the Cramp's Shipbuilding Co., Messrs. Wm. Sellers & Co., the Link-Belt Engineering Co., Messrs. Dodge & Day, and, more than all, to the Bethlehem Steel Co.

In carrying on this work more than ten machines have been fitted up at various times with special driving apparatus and the other needed appliances, all machines used since 1894 having been equipped with electric drives, so as to obtain any desired cutting speed. The thoroughness with which the work has been done may perhaps be better appreciated when it is understood that we have made between thirty and fifty thousand recorded experiments, and many others of which no record was kept. In studying these laws we have cut up into chips with our experimental tools more than 800,000 lbs. of steel and iron. More than sixteen thousand experiments were recorded in the Bethlehem Steel Co. We estimate that up to date between $150,000 and $200,000 have been spent upon this work, and it is a very great satisfaction to feel that those whose generosity has enabled us to carry on the experiments have received ample return for their money through the increased output and the economy in running their shops which have resulted from our experiments.

Throughout the whole 26 years we have succeeded in keeping almost all of these laws secret, and in fact since 1889 this has been our means of obtaining the money needed to carry on the work. We have never sold any information connected with this art for cash, but we have given to one company after another all of the data and conclusions arrived at through our experiments in consideration of the opportunity of still further continuing our work. In one shop after another, machines have been fitted up for our use, workmen furnished us to run them, and especially prepared tools, forgings and castings supplied in exchange for the data which we had obtained to date; and we have the best indication that they received full value for the money spent from the fact that the same company fitted up for us at intervals of several years three sets of apparatus, the additional knowledge obtained each time evidently warranting them in making the added outlay.

During this period all of the companies who were given this information, and all of the men who worked upon the experiments, were bound by promises to the writer not to give any of this information away nor to allow it to be published. Most of these promises were verbal; and in this day when there is so much talk about dishonesty and graft in connection with some of our corporations and prominent business men, it is a notable fact that through a period of 26 years it has not come to our knowledge that any one of the many men or companies connected with this work has broken a promise. The writer has his doubts whether any other country can produce a parallel record of such widespread good faith among its engineers and mechanics.

It seems to us that the time has now come for the engineering fraternity to have the results of our work, in spite of the fact that this will cut off our former means of financing the experiments. However, we are in hopes that the money required to complete this work may be obtained from some other source.

The writer has no doubt that many of the discoveries and conclusions which mark the progress of this work have been and are well known to other engineers, and we do not record them with any certainty that we were the first to discover or formulate them, but merely to indicate some of the landmarks in the development of our own experiments, which to us were new and of value. The following is a record of some of our more important steps:

(A) In 1881, the discovery that a round-nosed tool could be run under given conditions at a much higher cutting speed and therefore turn out much more work than the old-fashioned diamond-pointed tool.

(B) In 1881, the demonstration that, broadly speaking, the use of coarse feeds accompanied by their necessarily slow cutting speeds would do more work than fine feeds with their accompanying high speeds.

(C) In 1883, the discovery that a heavy stream of water poured directly upon the chip at the point where it is being removed from the steel forging by the tool, would permit an increase in cutting speed, and, therefore, in the amount of work done of from 30 to 40%. In 1884, a new machine shop was built for the Midvale Steel Works, in the construction of which this discovery played a most important part, each machine being set in a wrought-iron pan in which was collected the water (supersaturated with carbonate of soda to prevent rusting), which was thrown in a heavy stream upon the tool for the purpose of cooling it. The water from each of these pans was carried through suitable drain pipes beneath the floor to a central well from which it was pumped to an overhead tank from which a system of supply pipes led to each machine. Up to that time, so far as the writer knows, the use of water for cooling tools was confined to small cans or tanks from which only a minute stream was allowed to trickle upon the tool and the work, more for the purpose of obtaining a water finish on the work than with the object of cooling the tool; and, in fact, these small streams of water are utterly inadequate for the latter purpose. So far as the writer knows, in spite of the fact that the shops of the Midvale Steel Works until recently have been open to the public since 1884, no other shop in this country was similarly fitted up until that of the Bethlehem Steel Co. in 1899, with the one exception of a small steel works which was an offshoot in personnel from the Midvale Steel Co.

(D) In 1883, the completion of a set of experiments with round-nosed tools; first, with varying thicknesses of feed when the depth of the cut was maintained constant; and, second, with varying depths of cut while the feed remained constant, to determine the effect of these two elements on the cutting speed.

(E) In 1883, the demonstration of the fact that the longer a tool is called upon to work continuously under pressure of a shaving, the slower must be the cutting speed, and the exact determination of the effect of the duration of the cut upon the cutting speed.

(F) In 1883, the development of formulas which gave mathematical expression to the two broad laws previously referred to. Fortunately these formulas were of the type capable of logarithmic expression and therefore suited to the gradual mathematical development extending through a long period of years, which resulted in the making of our slide rules, and the solving of the whole problem in 1901.

(G) In 1883, the experimental determination of the pressure upon the tool required on steel tires to remove cuts of varying depths and thickness of shaving.

(H) In 1883, the starting of a set of experiments on belting described in a paper published in "Transactions," Vol. 15 (1894).

(J) In 1883, the measurement of the power required to feed a round-nosed tool with varying depths of cut and thickness of shaving when cutting a steel tire. This experiment showed that *a very dull tool* required as much pressure to feed it as to drive the cut. This was one of the most important discoveries made by us, and as a result all steel-cutting machines purchased since that time by the Midvale Steel Co. have been supplied with feeding power equal to their driving power and very greatly in excess of that used on standard machine tools.

(K) In 1884, the design of an automatic grinder for grinding tools in lots and the construction of a tool room for storing and issuing tools ready ground to the men.

(L) From 1885 to 1889, the making of a series of practical tables for a number of machines in the shops of the Midvale Steel Co., by the aid of which it was possible to give definite tasks each day to the machinists who were running machines, and which resulted in a great increase in their output.

(M) In 1886, the demonstration that the thickness of the chip or layer of metal removed by the tool has a much greater effect upon the cutting speed than any other element, and the practical use of this knowledge in making and putting into everyday use in our shops a series of broad-nosed cutting tools which enabled us to run with a coarse feed at as high a speed as had been before attained with round-nosed tools when using a fine feed, thus substituting, for a considerable portion of the work, *coarse feeds and high speeds* for our old maxim of *coarse feeds and slow speeds.*

(N) In 1894 and 1895, the discovery that a greater proportional gain could be made in cutting soft metals through the use of tools made from self-hardening steels than in cutting hard metals; the gain made by the use of self-hardening tools over tempered tools in cutting soft cast iron being almost 90%, whereas the gain in cutting hard steels or hard cast iron was only about 45%. Up to this time, the use of Mushet and other self-hardening tools had been almost exclusively confined to cutting hard metals, a few tools made of Mushet steel being kept on hand in every shop for special use on hard castings or forgings which could not be cut by the tempered tools. This experiment resulted in substituting self-hardening tools for tempered tools for all "roughing work" throughout the machine shop.

(P) In 1894 and 1895, the discovery that in cutting wrought iron or steel a heavy stream of water thrown upon the shaving at the nose of the tool produced a gain in cutting speed of *SELF-HARDENING TOOLS* of about 33%. Up to this time the makers of self-hardening steel had warned users never to use water on the tools.

(Q) From 1898 to 1900, the discovery and development of the Taylor-White process of treating tools; namely, the discovery that tools made from chromium-tungsten steels when heated to the melting point would do from two to four times as much work as other tools.

(R) In 1899-1902, the development of our slide rules, which are so simple that they enable an ordinary workman to make practical and rapid everyday use in the shop of all the laws and formulas deduced from our experiments.

(S) In 1906, the discovery that a heavy stream of water poured directly upon the chip at the point where it is being removed from *CAST IRON* by the tool would permit an increase in cutting speed, and therefore, in the amount of work done, of 16%.

(T) In 1906, the discovery that by adding a small quantity of vanadium to tool steel to be used for making modern high speed chromium-tungsten tools heated to near the melting point, the hardness and endurance of tools, as well as their cutting speeds, are materially improved.

While many of the results of these experiments are both interesting and valuable, we regard as of by far the greatest value that portion of our experiments and of our mathematical work which has resulted in the development of the slide rule; i. e., the patient investigation and mathematical expression of the exact effect upon the cutting speed of such elements as the shape of the cutting edge of the tool, the thickness of the shaving, the depth of the cut, the quality of the metal being cut and the duration of the cut, etc. This work enables us to fix a daily task with a definite time allowance for each workman who is running a machine tool, and to pay the men a bonus for rapid work.

The gain from these slide rules is far greater than that of all the other improvements combined, because it accomplishes the original object, for which in 1880 the experiments were started; i. e., that of taking the control of the machine shop out of the hands of the many workmen, and placing it completely in the hands of the management, thus superseding "rule of thumb" by scientific control.

By far the most difficult and illusive portion of this work has been the mathematical side, first, finding simple formulas which expressed with approximate accuracy the effect of each of the numerous variables upon the cutting speed; and, second, finding a rapid method of using these formulas in the solution of the daily machine shop problems. Several times during the progress of this mathematical work, the writer, feeling himself completely baffled, has asked the expert assistance of some of the best mathematicians in the country. They all smiled when told that we expected to solve mathematically a problem containing *twelve variables*, and in each case, after keeping the formulas before them for a longer or shorter time, returned the problem to the writer with the statement that it belonged distinctly in the realm of "rule of thumb" or empiricism, and could be solved only by the slow method of trial and error.

In the investigation of an art such as that of cutting metals, and about which at the time our work was started there was so little scientific knowledge, two types of experiments are possible.

First, the thoroughly scientific type, in which, after an analysis of all the variable elements which affect the final result, an attempt is made to hold all of the elements constant and uniform, except the one variable which is under investigation, and this one is systematically changed and its effect upon the problem carefully noted. It is to this type that our experiments belong, thanks mainly to the fact that Mr. William Sellers (one of the most scientific experimenters of his day) was president of the Midvale Steel Co. when the writer started his work.

Second, the type of experiments in which the effect of two or more variables upon the problem is investigated at the same time and in the same experiment. This method is of course much quicker than the thoroughly scientific type, and it is largely for this reason, in the opinion of the writer, that almost all of the other experimenters in this field have chosen it. Several of the experiments of this type have proved most valuable and developed much useful information, and it is with hesitancy that the writer criticises the work of any of these experimenters, since he appreciates most keenly the difficulties under which they worked, and is grateful for the information contributed by them to the art. After much consideration, however, he has decided to point out what he believes to be a few errors made by these experimenters, with the same object which he has in indicating our own false steps: namely, that of warning future investigators against similar errors.

Almost the whole course of our experiments is marked by imperfections in our methods, which, as we have realized them, have led us to go again more carefully over the ground previously traveled. These errors may be divided into three principal classes: (A) The adoption of wrong or inadequate standards for measuring the effect of each of the variables upon the cutting speed. (B) Failure on our part from various causes to hold all of the variables constant except the one which was being systematically changed in order to study the effect of these changes upon the cutting speed. (C) The omission either through oversight or carelessness on our part of some one of the precautions which should be taken to insure accuracy, or failure to record some of the phenomena considered unimportant at the time, but which

afterward proved to be essential to a complete understanding of the facts.

In the second portion of this paper is given in detail a statement of the appliances, methods and principles which we believe to be necessary to use in order to obtain reliable results. For the purpose of a more general discussion of the subject, however, it seems important to anticipate this portion of the paper by describing in detail the standard which we have finally adopted as a true criterion for determining the effect of each of the variables upon the cutting speed.

The effect of each variable upon the problem is best determined by finding the exact rate of cutting speed (say, in feet per minute) which shall cause the tool to be completely ruined after having been run for 20 minutes under uniform conditions. For example, if we wish to investigate the effect which a change in the thickness of the feed has upon the cutting speed, it is necessary to make a number of tools which are in all respects uniform, as to the exact shape of their cutting edge, their clearance and lip angles, their chemical composition and their heat treatment. These tools must then be run one after another, each for a period of 20 minutes, throughout which time the cutting speed is maintained exactly uniform. Each tool should be run at a little faster cutting speed than its predecessor, until that cutting speed has been found which will cause the tool to be completely ruined at the end of 20 minutes (with an allowance of a minute or two each side of the 20-minute mark). In this way that cutting speed is found which corresponds to the particular thickness of shaving which is under investigation.

A change is then made in the thickness of the shaving, and another set of 20-minute runs is made, with a series of similar uniform tools, until the cutting speed corresponding to the new thickness of feed has been determined; and by continuing in this way all of the cutting speeds are found which correspond to the various changes of feed. In the meantime, every precaution must be taken to maintain uniform all the other elements or variables which affect the cutting speed, such as the depth of the cut and the quality of the metal being cut; and the rate of the cutting speed must be frequently tested during each 20-minute run to be sure that it is uniform. The cutting speeds corresponding to varying feeds are then plotted as points upon a curve, and a mathematical expression is found which represents the law of the effect of feed upon cutting speed. We believe that this standard or method of procedure constitutes the very foundation of successful investigation in this art, and it is from this standpoint that we propose to criticise both our own experiments and those made by other investigators.

It was only after about 14 years' work that we found that the best measure for the value of a tool lay in the exact cutting speed at which it was completely ruined at the end of 20 minutes. In the meantime, we had made one set of experiments after another as we successively found the errors due to our earlier standards, and realized and remedied the defects in our apparatus and methods; and we have now arrived at the interesting though rather humiliating conclusion that with our present knowledge of methods and apparatus, it would be entirely practicable to obtain through four or five years of experimenting all of the information which we have spent 26 years in getting. The following are some of the more important errors made by us:

We wasted much time by testing tools for a shorter cutting period than 20 minutes, and then having found that tools which were apparently uniform in all respects gave most erratic results (particularly in cutting steel) when run for a shorter period than 20 minutes; we erred in the other direction by running our tools for periods of 30 or 40 minutes each, and in this way used up in each single experiment so much of the forging that it was impossible to make enough experiments in cutting metal of uniform quality to get conclusive results. We finally settled on a run of 20 minutes as being the best all-round criterion, and have seen no reason for modifying this conclusion up to date.

We next thought a proper criterion for judging the effect of a given element upon the cutting speed lay in determining the particular cutting speed which would just cause a tool to be slightly discolored below the cutting edge at the end of the 20 minutes. After wasting six months in experimenting with this as our standard, we found that it was not a true measure; and then adopted as a criterion a certain definite dulling or rubbing away of the cutting edge. Later it was found, however, that each thickness of feed had corresponding to it a certain degree of dullness or injury to the cutting edge at which point regrinding was necessary (the thicker the shaving the duller the tool should be before grinding); and a third series of experiments was made with this as a standard. While experimenting on light forging, a standard dullness of tool was used which was just sufficient to push the forging and tool apart and so slightly alter the diameter of the work. All of these criterions were discarded, however, when in 1894 we finally hit upon the true standard, above described, of completely ruining the tool in 20 minutes.

As will be pointed out later in the paper, this standard demands both a very large and expensive machine to experiment with, and also large, heavy masses of metal to work upon, which is unfortunate; but we believe without apparatus and methods of this kind it is out of the question to accurately determine the laws which are sought. Experiments upon the art of cutting metals (at least those experiments which have been recorded) have been mainly undertaken by scientific men, mostly by professors. It is but natural that the scientific man should lean toward experiments which require the use of apparatus and that type of scientific observation which is beyond the scope of the ordinary mechanic, or even of engineers unless they have been especially trained in this kind of observation. It is perhaps for this reason more than any other that in this art several of those elements which are of the greatest importance have received no attention from experimenters, while far less fruitful although more complicated elements, have been the subject of extended experiments.

As an illustration of this fact we would call attention to two of the most simple of all of the elements which have been left entirely untouched by all experimenters, namely:

(a) The effect of cooling the tool through pouring a heavy stream of water upon it, which results in a gain of 40% in cutting speed; (b) the effect of the contour or outline of the cutting edge of the tool upon the cutting speed, which when properly designed results in an equally large percentage of gain.

Both of these elements can be investigated at comparatively small cost, and with comparatively simple apparatus, while that element which has received chief attention from experimenters, namely, the pressure of the chip on the tool, calls for elaborate and expensive apparatus and is almost barren of useful results. This should be a warning to all men proposing to make experiments in any field, first, to look thoroughly over the whole field, and, at least, carefully consider all of the elements from which any practical results may be expected; and then to select the more simple and elementary of these and properly investigate them before engaging in the more complicated work.

The most notable experiments in this art that have come to the writer's attention are those made at Manchester, England, during the years 1902 and 1903. All these experiments were made jointly by eight of the most prominent English manufacturing companies, among whom were Armstrong, Whitworth & Co.; Vickers' Sons & Maxim; John Brown & Co.; Thomas Firth & Sons; and others, who combined with the Manchester Association of Engineers and the Manchester Municipal School of Technology, the latter being principally represented by Dr. J. T. Nicolson, who made the final report, entitled "Experiments with a Lathe Tool Dynamometer," published in "Transactions," Vol. 25.

In 1901, a committee of the Verein Deutscher Ingenieure (Union of German Engineers), together with the managers of some of the larger engineering works in Berlin, made an interesting series of experiments which was published September 28, 1901, in the "Zeitschrift des Verein Deutscher Ingenieure." On November 15, 1905, there were published in Bulletin No. 2 of the University of Illinois, experiments made by Prof. L. P. Breckinridge and Henry B. Dirks.

The work of all these men belongs to the second type of experiments previously referred to, in which the joint effect of two or more variables is studied at the same time. In the case of the Manchester experiments, the work appears to have been, to a considerable extent, a test as to the all-round knowledge in the art of cutting metals possessed by eight of the prominent English firms. These firms each presented tools made from their own tool steel, treated their own way, and ground to whatever shapes and angles the particular company considered would do the largest amount of work. Each company was allowed to have one guess on each of the qualities of metal worked upon, with each change of feed and depth of cut, as to the cutting speed at which they believed their tool would do the most work. If, under this cutting speed, the tool failed to hold out throughout the stipulated period of time, they were then given no opportunity to find the exact cutting speed at which the tool would do its best work. And, on the other hand, in those cases in which a tool did good work throughout its specified period of time, no effort was made to find how much faster it could have run and still do good work.

A glance at Plates 13, 14 and 15 at the end of Dr. Nicolson's report shows the great variety in the shapes of the tools used in the experiments. Yet no effort was made to definitely determine which make of tool steel or which shape of the tool was best, or even in case a tool did exceptionally good work, no effort was made to determine whether this was due to the shape of the tool or to the quality and treatment of the tool steel. As was to be expected from any such test, each one of the eight companies repeatedly made guesses as to the proper speeds for their tools to run which were very wide of the mark. Yet in spite of this, it is notable that in each case some one of the eight firms guessed fairly close to the proper cutting speed, so that by selecting the best of these various guesses Dr. Nicolson, in writing the report, gives a very valuable and interesting table on p. 250 of the Manchester Report, summarizing the best speeds attained in cutting the soft, medium and hard steels, and the soft, medium and hard cast irons experimented on, in each case with four combined changes of depth of cut and thickness of feed.

This table conclusively proves the practical value of experiments of this nature, even when carried on in a thoroughly unscientific manner. There is, however, one element in these experiments which was very carefully investigated, and the results of which are of general scientific value; namely, the determination of the pressure of the chip or shaving upon the nose of the tool. That the conclusions reached as to pressure are of value is due to the fact that upon this particular element, neither the shape of the tool nor the composition or treatment of the tool has very great effect, and in each case the pressure of the chip upon the tool appears to have been carefully observed and tabulated, so that experiments which are valueless from a scientific standpoint for most of the elements, confirm substantially, as to the pressure of the chip on the tool, the results of some of our previous experiments on this element.

The writer has a great respect for Dr. Nicolson as an experimenter, as his later work in this field has shown him to be a thoroughly scientific investigator, but feels it necessary to call attention to an error which even he has fallen into, namely, that of attempting to deduce a formula for the cutting of metals from a summary of the Manchester and German experiments. These experiments, from a scientific standpoint, were so defective as to make it out of the question to deduce formulas, because no effort was made to keep the following variables uniform: (1) The shape of the cutting edge and the lip and clearance angles of the tool varied from one experiment to another; (2) the quality of the tool steel varied; (3) the treatment of the tool varied; (4) the depth of the cut varied from that aimed at; (5) the cutting speed was not accurately determined at which each tool would do its maximum work throughout a given period of time; and (6) in reading the report of these experiments it does not appear that any careful tests were made to determine whether each of the various forgings and castings experimented on was sufficiently uniform throughout in quality to render the tests made upon them of scientific value. The same criticism, broadly speaking, applies to both the German and the University of Illinois experiments.

In fact, in none of these sets of experiments have they appreciated the necessity of *measuring separately* the effect produced upon the cutting speed by two of the most important elements in the problem, (a) the thickness of the feed, and (b) the depth of the cut. In all of these investigations and in formulas given by Dr. Nicolson on p. 249 of the Manchester report, as well as in a formula published by him in "Technics," for January, 1904, summarizing the results of the Manchester and German experiments, the area of the cut "a" is used as though it were a single variable, whereas the sectional area of the shaving is, in fact, the product of the depth of the cut multiplied by the feed. The fact is, however, that the thickness of the shaving or the feed has a greater effect upon the cutting speed than any other element, while the depth of the cut has only a comparatively small effect. When this is realized, it becomes apparent that any formula or even any data containing the area of the cut (or shaving) as a single element is valueless from a scientific standpoint. To illustrate: a cut which is ½-in. deep with $^1/_{32}$-in. feed has the same sectional area as a ⅛-in. depth cut by ⅛-in. feed; namely, $^1/_{64}$-in. sectional area. Our experiments show that if a cutting speed for a ½-in. by ⅛-in. cut were 10 ft. per minute, then the cutting speed for a ½-in. by $^1/_{32}$-in. cut would be 18 ft. per minute. From which the impossibility of using the area of the cut as an element in a formula is apparent.

Broadly speaking, it is unwise to draw conclusions and make formulas from experiments in which more than one variable is allowed to vary in the same trial. This criticism is made in no sense to belittle the value of the work done by others, but with the object to pointedly call the attention of future experimenters to such errors as have been made primarily by ourselves and also by others.

The results obtained by Dr. Nicolson from the Manchester experiments led him to make another set of experiments for the purpose of determining accurately the pressure of the chip or shaving upon the cutting edge of the tool. In carrying out this work Dr. Nicolson has designed and constructed what appears to be by far the most scientific apparatus which has yet been made for this purpose. In his paper (published in "Transactions," Vol. 25), he has very fully illustrated the apparatus with which he weighs separately the pressure of the chip upon the tool in three directions: (a) the VERTICAL PRESSURE; (b) the outward pressure or the pressure horizontally at right angles to the axis of the piece being turned, called by him SURFACING PRESSURE; (c) the feeding pressure or the pressure horizontally parallel to the axis of the piece being turned; called by him TRAVERSING PRESSURE.

His determination of that lip angle of the tool which cuts the metal with the least pressure was of great interest; but, in the writer's judgment, by far the most important and original fact developed by him was brought out by a series of experiments in which he determined the wave-like increase and decrease of the pressure upon the nose of the tool which occurs in cutting metals. In these experiments the chip was removed at a cutting speed of about 1 ft. in five hours. It is notable that no other apparatus heretofore designed was sufficiently scientific and accurate to demonstrate this fact. His discovery is most important in explaining one of the causes for the chattering of tools, and becomes a thoroughly scientific aid in selecting the shape or contour of the cutting edge for standard tools to be used in "roughing work."

These experiments form a substantial and permanent addition to our knowledge of the art of cutting metals; and the writer regrets that Dr. Nicolson has not since then investigated other elements immediately affecting the more vital problem of the cutting speed in a similarly thorough manner; since he chose for investigation that element which on the whole is least fruitful in its practical results upon the art of cutting metals, namely, the pressure of the chip upon the tool.

However, in choosing this element for investigation Dr. Nicolson made the same error (if such it may be called) into which almost every experimenter in this field falls sooner or later. From all theoretical standpoints it appears to the novice that a thorough investigation of the effect of the pressure of the chip upon the tool under varying conditions must furnish the key to the whole problem of the variation of cutting speed due to varying feeds, depths of cut, shape of the tool, etc. The fact is, however, that every one who exploits this field finds out sooner or later that there is no traceable relation whatever between the pressure of the chip on the tool and the cutting speed, and but little connection even between the hardness of the metal and the pressure upon the tool. The following is the reasoning which has led us all, at one time or another, into the same error:

The ultimate cause for a tool giving out when cutting metal is the dullness or wear of the tool produced by the rubbing or pressure of the chip upon the lip surface of the tool, and the chief element causing this wear, particularly at the high speeds at which tools should be run to do their best work, is the softening of the tool due to the heat produced by the friction of the chip upon its lip surface. Now, it seems perfectly evident that this heat will be increased directly in proportion to three elements: (a) the pounds of pressure of the chip upon the tool; (b) the speed with which the chip slides across the nose of the tool; (c) the coefficient of friction between the chip and the surface of the tool. And yet, paradoxical as it may seem, the writer again repeats that there is no traceable relation between the pressure of the chip upon the tool and the cutting speed.

So convincing, however, is the above theory that each successive experimenter who has joined the writer in his work has been thoroughly convinced that, through some error in our early experiments upon the pressure of the chip on the tool, we failed to establish the relation between the pressure and the cutting speed which would be demonstrated by a more carefully tried set of experiments; and the writer thinks it is not an exaggeration to state that each of these men in succession remained unconvinced until he had had the opportunity of verifying this fact for himself.

As an illustration of the mental effect of this theory upon these experimenters: In one case, a bright and thoroughly honest young man, who was employed by the writer to help on the mathematical side of this work, became so thoroughly convinced through the above reasoning that the main lines on which we were carrying on our investigation would be rendered entirely unnecessary by a series of pressure tests made by himself, that upon being told by the writer he would not allow the expense to be incurred for another series of pressure tests, he wrote a memorial of many pages to the Board of Directors of the company in which the experiments were being carried on, explaining his own thorough scientific attainments and the writer's lack of the same, and that, therefore, our relative positions ought to be reversed, that he should do the directing and the writer should do the work. And, finally, when his protests were not heeded, he resigned his position; and the writer has been told that he subsequently induced another company to allow him to experiment on his own account. However, up to date there has not appeared any published report of these experiments.

We are dwelling at such length upon this element in the art because it has constituted the pit into which so many experimenters have fallen; and upon failing to trace any scientific relation between the pressure and the cutting speed they are very apt to conclude that the whole subject of cutting metals belongs to the domain of "rule of thumb" rather than to that of exact science, and give up further work in this field. It may almost be said that investigations heretofore made upon the general subject of the pressure of the chip upon the tool have proved barren of useful and practical results, except in so far as they have furnished the knowledge needed by tool builders for giving their machines the proper driving power. It is with little hesitation that the writer makes the assertion that if no experiments whatever had been made in this field, the knowledge of the art of cutting metals would be on the whole in a more advanced state than it is now, since experimenters in all countries instead of studying pressures would have given their attention to some one of the other lines of investigation which bear directly and yield valuable information upon the one most important subject of cutting speed.

It is a noteworthy fact that when thorough investigations are attempted by earnest men in new fields, while frequently the object aimed at is not attained, yet quite often discoveries are made which are entirely foreign to the purpose for which the investigation was undertaken. And it may be said that the indirect results of careful scientific work are, generally speaking, fully as valuable as the direct. Two interesting illustrations of this fact have been furnished by our experiments.

The discovery of the Taylor-White process of treating tools by heating them almost to the melting point, or, in other words, the introduction of modern high speed tools the world over, was the indirect result of one of our lines of investigation. The demonstration of the fact that the rules for using belting in common practice furnished belts which were entirely too light for economy was also one of the indirect results of our experiments. The manner of making these discoveries was each time in a way so typical of what may be expected in similar cases that it would seem worth while to describe it in some detail.

During the winter of 1894-1895, the writer conducted an investigation in the shop of Wm. Sellers & Co., at the joint expense of Messrs. William Cramp & Sons, shipbuilders, and Messrs. Wm. Sellers & Co., to determine which make of self-hardening tool steel was, on the whole, the best to adopt as standard for all of the roughing tools of these two shops. As a result of this work, the choice was narrowed down at that time to two makes of tool steel: (1) the celebrated Mushet self-hardening steel, the chemical composition of the particular bar analyzed at this time being as follows:

Tungsten	Chromium	Carbon	Manganese	Silicon	Phosphorus	Sulphur
%	%	%	%	%	%	%
5.441	0.398	2.150	1.578	1.044	....	....

and (2) a self-hardening steel made by the Midvale Steel Co. of the following chemical composition:

Tungsten	Chromium	Carbon	Manganese	Silicon	Phosphorus	Sulphur
%	%	%	%	%	%	%
7.723	1.830	1.143	0.180	0.246	0 023	0.008

Of these two steels, the tools made from the Midvale steel were shown to be capable of running at rather higher cutting speeds. The writer himself heated hundreds of tools of these makes in the course of his experiments in order to accurately determine the best temperatures for forging and heating them prior to grinding so as to get the best cutting speeds. In these experiments he found that the Mushet steel if overheated crumbled badly when struck even a light blow on the anvil, while the Midvale steel if overheated showed no tendency to crumble, but, on the other hand, was apparently permanently injured. In fact, heating these tools slightly beyond a bright cherry red caused them to permanently fall down in their cutting speeds; and the writer was unable at that time to find any subsequent heat treatment which would restore a tool broken down in this way to its original good condition. This defect in the Midvale tools left us in doubt as to whether the Mushet or the Midvale was, on the whole, the better to adopt as a shop standard.

In the summer of 1898, soon after undertaking the reorganization of the management of the Bethlehem Steel Co., the writer decided to continue the experiments just referred to with a view to ascertaining whether in the meanwhile some better tool steel had not been developed. After testing several additional makes of tools, our experiments indicated that the Midvale self-hardening tools could be run if properly heated at slightly higher speeds than those of any other make. Upon deciding to adopt this steel as our standard the writer had a number of tools of each make of steel carefully dressed and ground to exactly the same shape. He then called the foremen and superintendents of the machine shops of the Bethlehem Steel Co. to the experimental lathe so that they could be convinced by seeing an actual trial of all of the tools that the Midvale steel was, on the whole, the best. In this test, however, the Midvale tools proved to be worse than those of any other make; i. e., they ran at slower cutting speeds. This result was rather humiliating to us as experimenters who had spent several weeks in the investigation.

It was of course the first impression of the writer that these tools had been overheated in the smith shop. Upon careful inquiry among the smiths, however, it seemed as though they had taken special pains to dress them at a low heat, although the matter was left in much doubt. The writer, therefore, determined to make a thorough investigation before finally adopting the Midvale steel as our shop standard to discover if possible some heat treatment which would restore Midvale tools injured in their heating (whether they had been underheated or overheated) to their original good condition.

For this purpose Mr. White and the writer planned a carefully laid-out series of experiments, in which tools were to be heated at temperatures increasing, say, by about 50° all the way from a black heat to the melting point. These tools were then to be ground and run in the experimental lathe upon a uniform forging, so as to find: (a) that heat at which the highest cutting speed could be attained (which our previous experiments had shown to be a cherry red); (b) to accurately determine the exact danger point at which if over or underheated these tools were seriously injured; (c) to find some heat treatment by which injured tools could be restored to their former high cutting speeds.

These experiments corroborated our Cramp-Sellers experiments, showing that the tools were seriously broken down or injured by overheating, say, somewhere between 1,550° F. and 1,700° F.; but to our great surprise, tools heated up to or above the high heat of 1,725° F. proved better than any of those heated to the best previous temperature, namely, a bright cherry red; and from 1,725° F. up to the incipient point of fusion of the tools, the higher they were heated, the higher the cutting speeds at which they would run. Thus, the discovery that phenomenal results could be obtained by heating tools close to the melting point, which was so completely revolutionary and directly the opposite of all previous heat treatment of tools, was the indirect result of an accurate scientific effort to investigate as to which brand of tool steel was, on the whole, the best to adopt as a shop standard; neither Mr. White nor the writer having the slightest idea that overheating beyond the bright cherry red would do anything except injure the tool more and more the higher it was heated.

During our early Midvale Steel Co. experiments, extending from 1880 to 1883, the writer had so much trouble in maintaining the tension of the belt used in driving the boring mill upon which he was experimenting that he concluded: (1) that belting rules in common use furnished belts entirely too light for economy; and (2) that the proper way to take care of belting was to have each belt in a shop tightened at regular intervals with belt clamps especially fitted with spring balances, with which the tension of the belt was accurately weighed every time it was tightened, each belt being retightened each time to exactly the same tension.

In 1884, the writer designed and superintended the erection of a new machine shop for the Midvale Steel Co., and this gave him the opportunity to put these conclusions to a practical test. About half the belts in the shop were designed according to the ordinary rules and the other half were made about three times as heavy as the usual standard. This shop ran day and night. The belts were in all cases cared for and retightened only upon written orders sent from the shop office, and an accurate record was kept through nine years of all items of interest concerning each belt, namely: the number of hours lost through interruption to manufacture; the number of times each belt interrupted manufacture; the original cost of each belt; the detail costs of tightening, cleaning, and repairing each belt; the fall in the tension before requiring retightening; and the time each belt would run without being retightened. Thus at the end of nine years these belts furnished a record which demonstrated beyond question many important facts connected with the use of belting, the principal of these being that the ordinary rules gave belts only about one-half as heavy as should be used for economy.* This belting experiment illustrates again the good that often comes indirectly from experiments undertaken in an entirely different field.

After many years of close personal contact with our mechanics, I have great confidence in their good judgment and common sense in the long run, and I am proud to number many of them among my most intimate friends. As a class, however, they are extremely conservative, and if left to themselves their progress from the older toward better methods will be exceedingly slow. And my experience is that rapid improvement can only be brought about through constant and heavy pressure from those who are over them. It must be said, therefore, that to get any great benefit from the laws derived from these experiments, our slide rules must be used, and these slide rules will be of little, if any, value under the old style of management, in which the machinist is left with the final decision as to what shape of tool, depth of cut, speed, and feed, he will use.

*The writer presented a paper to the Am. Soc. M. E. in 1903 (published in "Transactions," Vol. 15) upon this series of experiments. He has since found, however, that in the minds of many readers the value of the conclusions arrived at have been seriously brought into question largely through the criticism of one man, which at the time appeared to the writer so ridiculous that he made the mistake of thinking it not worth answering in detail. This should be a warning to writers to answer carefully all criticisms, however foolish.

The slide rules cannot be left at the lathe to be banged about by the machinist. They must be used by a man with reasonably clean hands, and at a table or desk, and this man must write his instructions as to speed, feed, depth of cut, etc., and send them to the machinist well in advance of the time that the work is to be done. Even if these written instructions are sent to the machinist, however, little attention will be paid to them unless rigid standards have been not only adopted, but *enforced*, throughout the shop for every detail, large and small, of the shop equipment, as well as for all shop methods. And, further, but little can be accomplished with these laws unless the old style foreman and shop superintendent have been done away with, and functional foremanship has been substituted,—consisting of speed bosses, gang bosses, order-of-work men, inspector, time study men, etc. In fact, the correct use of slide rules involves the substitution of our whole task system of management for the old style management, as described in our paper on "Shop Management" ("Transactions," Vol. 24). This involves such radical, one might almost say, revolutionary, changes in the mental attitude and habits both of the workmen and of the management, and the danger from strikes is so great and the chances for failure are so many, that such a reorganization should only be undertaken under the direct control (not advice but *control*) of men who have had years of experience and training in introducing this system.

A long time will be required in any shop to bring about this radically new order of things; but in the end the gain is so great that I say without hesitation there is hardly a machine shop in the country whose output cannot be doubled through the use of these methods. And this applies not only to large shops, but also to comparatively small establishments. In a company whose employes all told, including officers and salesmen, number about 150 men, we have succeeded in more than doubling the output of the shop, and in converting an annual loss of 20% upon the old volume of business into an annual profit of more than 20% upon the new volume of business, and at the same time rendering a lot of disorganized and dissatisfied workmen contented and hard working, by insuring them an average increase of about 35% in their wages. And I take this opportunity of again saying that those companies are indeed fortunate who can secure the services of men to direct the introduction of this type of management who have had sufficient training and experience to insure success.*

Unfortunately those fundamental ideas upon which the new task management rests mainly for success are directly antagonistic to the fundamental ideas of the old type of management. To give two out of many examples: Under our system the workman is told minutely just what he is to do and how he is to do it; and any improvement which he makes upon the orders given is fatal to success. With the old style, the workman is expected to constantly improve upon his orders and former methods. Under our system, any improvement, large or small, once decided upon goes into immediate use, and is never allowed to lapse or become obsolete, while under the old system, the innovation unless it meets with the approval of the mechanic (which it never does at the start) is generally for a long time, at least, a positive impediment to success. Thus, many of those elements which are mainly responsible for the success of our system are failures and a positive clog when grafted on to the old system. For this reason the really great gain which will ultimately come from the use of these slide rules will be slow in arriving—mainly, as explained, because of the revolutionary changes needed for their successful use—but it is sure to come in the end.

Too much emphasis cannot be laid upon the fact that standardization really means simplification. It is far simpler to have in a standardized shop two makes of tool steel than to have 20 makes of tool steel, as will be found in shops under the old style of management. It is far simpler to have all of the tools in a standardized shop ground by one man to a few simple but rigidly maintained shapes than to have, as is usual in the old style shop, each machinist spend a portion of each day at the grindstone, grinding his tools with radically wrong curves and cutting angles, merely because bad shapes are easier to grind than good. Hundreds of similar illustrations could be given showing the true simplicity (not complication) which accompanies the new type of management.

There is, however, one element in which the new type of management to all outward appearances is far more complicated than the old; namely, no standards and no real system of management can be maintained without the supervision and, what is more, the hard work of men who would be called by the old style of management supernumeraries or non-producers. The man who judges of the complication of his organization only by looking over the names of those on the pay-roll and separating the so-called non-producers from the producers, finds the new style of management more complicated than the old.

No one doubts for one minute that it is far simpler to run a shop with a boiler, steam engine, shafting, pulleys and belts than it would be to run the same shop with the old-fashioned foot power, yet the boiler, steam engine, shafting, pulleys and belts require, as supernumeraries or non-producers on the pay-roll, a fireman, an engineer, and oiler and often a man to look after belts. The old style manager, however, who judges of complication only by comparing the number of non-producers with that of the producers, would find the steam engine merely a complication in management. The same man, to be logical, would find the whole drafting force of an engineering establishment merely a complication, whereas in fact it is a great simplification over the old method.

Now our whole system of management is quite accurately typified by the substitution of an elaborate engine to drive and control the shop in place of the old-fashioned foot power. There is no question that our human managing machine, which is required for the maintenance and the effective use of both standard shop details, and standard methods throughout the establishment, calls for many more non-producers than are used with the old-style management having its two or three foremen and a superintendent. The efficiency of our engine of management, however, compared with the old single foreman is like a shop engine as compared with foot power or the drafting room as compared with having the designing done by the pattern-maker, blacksmith, and machinist.

A study of the recommendations made throughout this paper will illustrate the fact that we propose to take all of the important decisions and planning which vitally affect the output of the shop out of the hands of the workmen, and centralize them in a few men, each of whom is especially trained in the art of making those decisions and in seeing that they are carried out, each man having his own particular function in which he is supreme, and not interfering with the functions of other men. In all this let me say again that we are aiming at true simplicity, not complication.

There is one recommendation, however, in modern machine shop practice in making which the writer will probably be accused of being old-fashioned or ultra-conservative. Of late years there has been what may be almost termed a blind rush on the part of those who have wished to increase the efficiency of their shops toward driving each individual machine with an independent motor. The writer is firmly convinced through large personal observation in many shops and through having himself systematized two electrical works that in perhaps three cases out of four a properly designed belt drive is preferable to the individual motor drive for machine tools. There is no question that through a term of years the total cost, on the one hand, of individual motors and electrical wiring, coupled with the maintenance and repairs, of this system will far exceed the first cost of properly designed shafting and belting plus maintenance and repairs. In most shops, entirely too light belts and counter-shafts of inferior design are used, and the belts are not systematically cared for by one trained man; this involves a heavy cost for maintenance. There is no question, therefore, that in many cases the motor drive means in the end additional complication and expense rather than simplicity and economy. There is little, if any, economy in power obtainable through promiscuous motor driving, and it will certainly be found to be a safe rule not to adopt an individual motor for driving any machine tool unless a large saving can be made by it.

In concluding, let me say that we are now but on the threshold of the coming era of true co-operation. The time is fast going by for the great personal or individual achievement of any one man standing alone and without the help of those around him. And the time is coming when all great things will be done by the co-operation of many men in which each man performs that function for which he is best suited, each man preserves his own individuality and is supreme in his particular function, and each man at the same time loses none of his originality and proper personal initiative, and yet is controlled by and must work harmoniously with many other men. And let me point out that the most important lessons taught by these experiments, particularly to the younger men, are:

(A) SEVERAL MEN WHEN HEARTILY CO-OPERATING, EVEN IF OF EVERYDAY CALIBER, CAN ACCOMPLISH WHAT WOULD BE NEXT TO IMPOSSIBLE FOR ANY ONE MAN EVEN OF EXCEPTIONAL ABILITY.

(B) EXPENSIVE EXPERIMENTS CAN BE SUCCESSFULLY CARRIED ON BY MEN WITHOUT MONEY, AND THE MOST DIFFICULT MATHEMATICAL PROBLEMS CAN BE SOLVED BY VERY ORDINARY MATHEMATICIANS; PROVIDING ONLY THAT THEY ARE WILLING TO PAY THE PRICE IN TIME, PATIENCE, AND HARD WORK.

(C) THE OLD ADAGE IS AGAIN MADE GOOD THAT "ALL THINGS COME TO HIM WHO WAITS," IF ONLY HE WORKS HARD ENOUGH IN THE MEANTIME.

*The writer feels free to give this advice most emphatically without danger of having his motives misinterpreted, since he has himself given up accepting professional engagements in this field.

THE USE OF TIDAL POWER FOR COMPRESSING AIR AT ROCKLAND, ME.

By Wm. O. Webber,* M. Am. Soc. M. E.

It has been erroneously stated that the Rockland Power Co., of Rockland, Me. is making experiments in the use of the Taylor system of air compression, to compress air by tidal power. The plants at Norwich, Conn. (Eng. News, June 12, 1902, p. 470), Victoria Mines, Rockland, Mich., Magog, Quebec (Eng. News, May 30, 1901, p. 406), and Peterboro, Ontario, embody the Taylor system.

The plant which is in contemplation at Rockland, Maine, is really a return to the older methods of Frizell (Eng. News, Oct. 31, p. 345; Nov. 7, p. 354, and Nov. 14, 1878, p. 361), with the addition of modern improvements covered by American and foreign patents granted to the writer.

Careful experiments upon a large working model, erected at South Thomaston, Maine, last summer, have fully demonstrated the peculiar application necessary for the utilization of the flow between large tidal basins and the ocean. They also demonstrated that an economical compression of air can be accomplished with much less differences in water level than was claimed by Frizell.

At South Thomaston there is a tidal basin with an area of slightly over a square mile, or 640 acres. The average rise and fall of the tide at this point is 12 ft. This would, therefore, realize about 5,000 H.P. on the basis of 70% efficiency of the compressing apparatus, which should be easily obtained, as the tests of the other plants mentioned have given much higher efficiencies.

The "head of fall," or difference of level, in the case of tidal flow, simply governs the ratio of air that can be entrained with a given volume of water, and has nothing to do with the pressure. The depth at which the separation of the entrained air from the water takes place below the surface governs the pressuse, and it has been demonstrated that, with a fall of 35 ft., the highest ratios of efficiency can be obtained, with the maximum ratios of air to water. At lower heads equally good efficiencies can be obtained, but at lower ratios of air to water.

It is practical to arrange for storage chambers, connected with the separating chamber, sufficiently large to store air to the average capacity of the compressor, in order to cover the period of time at flood and ebb tide when the compressor would, either, not work at all, or else work at such low efficiencies as to be commercially impracticable. At Rockland, Maine, there is sufficient market for the available power in the stone and lime quarries and factories of the country, within a 20-mile radius.

Contrary to the usually preconceived notions, it is practicable to transmit compressed air through pipes, long distances, with comparatively slight losses. It has been demonstrated by the Popp system, in Paris, that the leakage is very slight, and the four year's experience, at Norwich, Conn., shows the leakage to be nil. Hydraulically compressed air being a perfectly dry gas, the frictional resistance, in good, smooth-coated pipe, is remarkably low, and velocities of 50 to 70 ft. a second are admissible. The cost of pipe lines is not so greatly in excess of electrical transmission lines, when the cost of step up and step down transformers, etc., are taken into consideration.

There are many tidal basins along the coasts of the temperate zones, between the 40th and 50th parallels of latitude, which are commercially capable of developing in this manner an unfailing source of power. Moreover this source of power has no dry season in the summer and the cutting off of forests does not affect it. This power can be made available many miles inland from the shore at comparatively low costs, and, with

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the single exception of lighting, can be turned into useful work in direct competition with electrical power.

The scheme at Rockland having been financed, work will begin in the early spring on the construction of the dam and the laying of pipe lines to the quarries of the Rockland, Rockport Lime Co., to the power-house of the Rockland, Thomaston & Camden St. Ry., and to several cities in whose streets distribution mains will be laid the same as gas pipes. It is expected that the plant will be completed in the fall of 1907.

TUNNEL LINING WORK IN THE FAR WEST.

RELINING THE HODGES PASS TUNNEL: OREGON SHORT LINE RY.—The Hodges Pass tunnel on the Oregon Short Line Ry. is 43.2 miles west of Granger, Wyo., at an elevation of 7,038 ft. above sea level. It is 1,425.8 ft. long between portals, all on tangent, with grades of 0.225% and 0.235% on each side of the summit, and a maximum grade of 0.64%, the changes in grade being made by vertical curves. It passes through a variety of strata of rock and clay, with seams of coal, slate and soapstone. The tunnel was built in 1882-3, and originally had a timber lining, but has now been relined with concrete and brick. This work was commenced in 1898 and completed in 1900, being carried on only at intervals. About 25% of the work was done by a contractor, who then abandoned it, and it was completed by the railway company's forces. When the relining was undertaken, Mr. J. C. O'Melvany was Chief Engineer, and Mr. J. Q. Barlow (now Chief Engineer of the Western Maryland Ry.) was in direct charge. The work was completed under the direction of Mr. Wm. Ashton, the present Chief Engineer of the Oregon Short Line Ry., to whom we are indebted for plans and information. Mr. A. I. Fonda, Assistant Engineer, was in direct charge of the work.

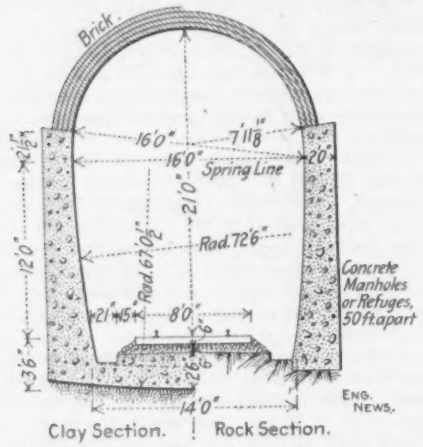


Fig. 1. Cross-Sections of the Hodges Pass Tunnel as Relined; Oregon Short Line Ry. Wm. Ashton, Chief Engineer.

Typical cross sections are shown in Fig. 1. The concrete invert, however, was required only for about one-third of the length of the tunnel; on the balance of the work the concrete walls were put in on a rock floor, as shown. The brick arch was also built in the style shown for only about one-third of the length; for the remainder of the work the concrete was carried up so as to use the brick only in the top of the arch; that is, one-third of the arch forming the top was closed with brick. The balance of the arch was built of concrete, and Mr. Ashton is of opinion that in similar work he would leave out the brick entirely, although thus far there has been no indication of any failure of the brick, either where the whole arch or only the central portion was of brick.

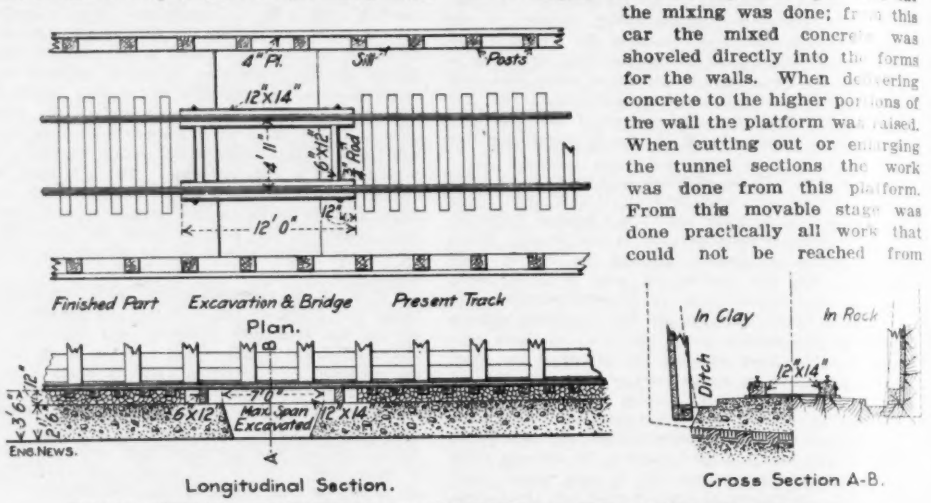


FIG. 2. METHOD OF PUTTING IN CONCRETE INVERT; HODGES PASS TUNNEL.

For putting in the invert, the ties and ballast were removed for a length of about 12 ft., and 12-ft. timbers, 12 x 14 ins., were put under the rails; near each end a 6 x 12-in. cross timber was framed into the longitudinals and a ¾-in. tie rod put through them. The floor was then excavated for a length not exceeding 7 ft., and the concrete filled in. This is shown in Fig. 2. Alternative methods of putting in the side walls are shown in Fig. 3. In plan A, the concreting is done continuously on a certain length of the work; in plan B it is done in alternate sets of panels. In both cases the forms are of similar construction, with posts resting on sills and secured by braces against the ends of the ties. In plan A, however, the tops of the posts are framed into short horizontal timbers resting in recesses in the tunnel face, while in plan B the tops of the posts are notched to fit against the old caps of the original timber lining, to which caps the posts were bolted.

The arch centering, Fig. 4, consisted of four bents, 3 ft. c. to c., resting upon sills 12 ft. long. This centering was supported on each side by three screw jacks set upon mudsills laid on the invert or in the ditch of the rock floor. When the centering was to be moved, the jacks were slacked off so as to lower the timber pedestals onto the small trucks with rollers running on the mudsills. The details of the arch centering are shown in Fig. 5.

The concrete was usually composed of 1 part of cement, 3 parts of sand and 5 parts of 2½-in. crushed stone. It was all mixed by hand, and for the greater part of the work it was placed in the tunnel. A flat car, with a deck adjustable as to height, was fitted up, and upon this car the mixing was done; from this car the mixed concrete was shoveled directly into the forms for the walls. When delivering concrete to the higher portions of the wall the platform was raised. When cutting out or enlarging the tunnel sections the work was done from this platform. From this movable stage was done practically all work that could not be reached from the ground. When necessary to clear the tunnel for trains, the car and all stagings, mortar boxes, etc., were run out of the tunnel onto spur tracks conveniently located beyond the portals. Here the car remained until the smoke from the trains had sufficiently cleared to permit of work being resumed in the tunnel.

The average amount of traffic was about six trains each way per day, and the work was handled in such a way as to clear all regular passenger trains. Freight trains, however, were to some extent regulated as to their use of the tunnel so as to limit the interference with the work; for this purpose day trains were preferably spaced so as to follow the time of passenger trains in passing through the tunnel, or when this was not practicable they were passed through the tunnel during the noon hour, and in some cases at other times during working hours. The passage of all trains other than regular passenger trains was arranged with the engineer

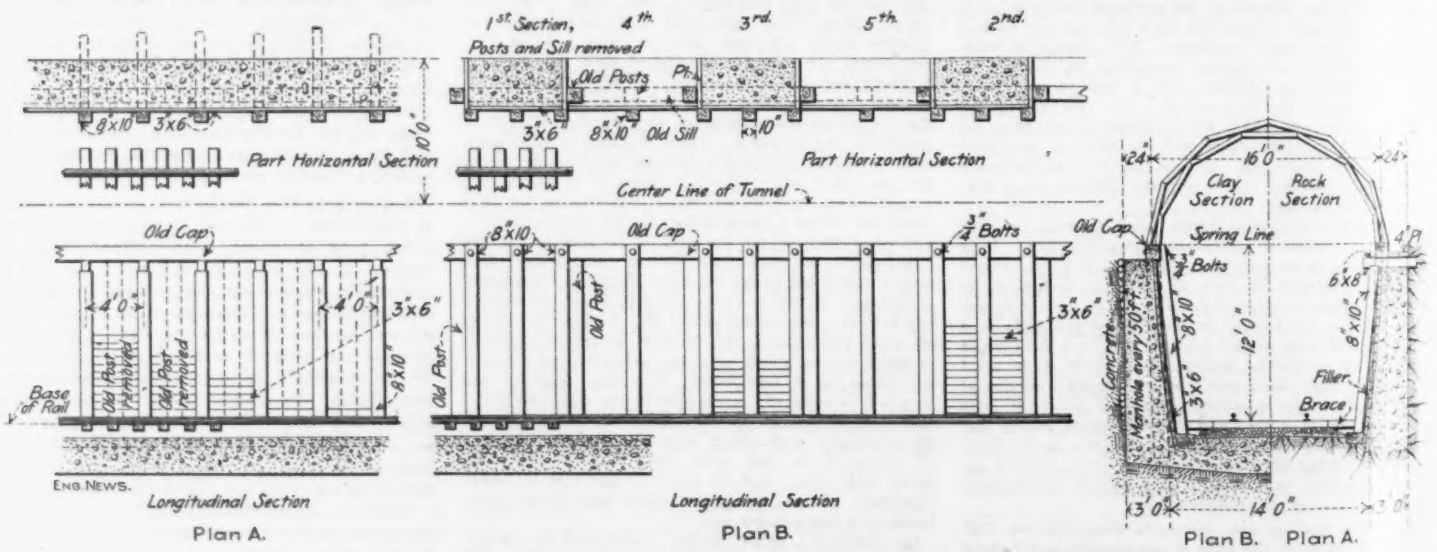


FIG. 3. ALTERNATIVE PLANS FOR BUILDING CONCRETE SIDE WALLS; HODGES PASS TUNNEL.

in charge of the tunnel work so as to best suit his convenience without unnecessary delay on the work. By this arrangement freight trains were frequently scheduled so as to meet at the tunnel or to pass through the tunnel in two sections, so as to interfere with the work as little as possible. In order to protect the work against trains a telegraph station was established at the tunnel, and no train was allowed to enter the tunnel at any time without display of proper signals authorized by the engineer in charge of the work.

The number and distribution of men in the working gangs depended a great deal upon the character of the work being done. In some cases the placing of the concrete would be delayed until difficult formation had been passed or slides held. From 12 to 16 men, as a rule, were found to be all that could be conveniently employed in the removal of the old timber lining and the placing of the new concrete lining inside the tunnel.

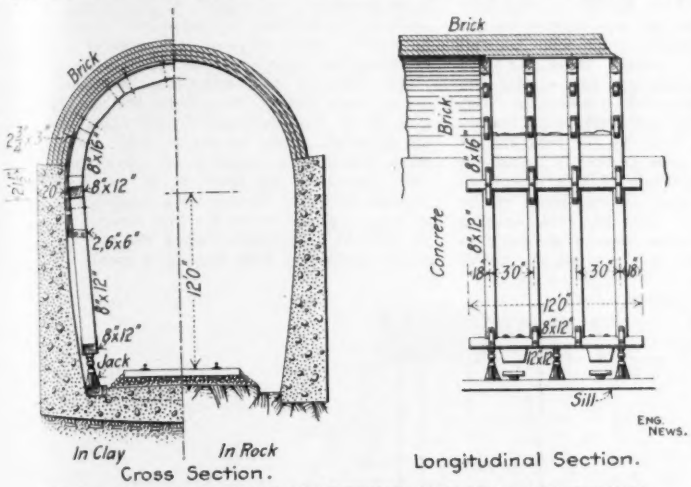


FIG. 4. PORTABLE ARCH CENTERING; HODGES PASS TUNNEL.

For lighting the work, kerosene oil torches were used for the most part; lamps with reflectors were also used to some extent. For a distance of about 150 ft. a considerable amount of water was encountered, and considerable water still flows into the tunnel through weep holes left for this purpose. This water, with the soft material in which it was found, somewhat delayed the progress of the work, but no special difficulty was found in controlling it. The water and dampness at this point still give a little trouble in winter by seeping through the arch and forming icicles. The smoke and gas from passing trains gave trouble only in the delay it caused to the work, but under ordinary conditions 15 to 20 minutes would allow the tunnel to clear sufficiently to permit the resumption of work.

Owing to the destruction of the engineer's office by fire, it is not practicable to give the itemized figures of cost, but the records of the auditor's office indicate the total cost of the lining of this tunnel to be as follows: Labor, $21,129; material, $13,939; total, $35,068. As about one-third of this tunnel was built with an invert, which added very materially to the cost, and as a considerable portion of the expense of the relining consisted in enlarging the section and taking down and refilling slides, the total cost gives very little idea as to the cost per lineal foot chargeable to the relining.

TIMBER LINING FOR TUNNELS: SOUTHERN PACIFIC RY.—In the reconstruction work of the Southern Pacific Ry., between Reno, Nev., and Ogden, Utah, timber lining is used for the tunnels, and the form of timbering used is shown in Fig. 6. This is from a drawing furnished us by Mr. Ashton. The construction is clearly shown and calls for little description, but attention may be called to the large size of the tunnel in clear dimensions. The clear width is 17 ft. between posts, and the clear height from base of rail is 21 ft. 9 ins. to the crown. The wide clearance which this gives for rolling stock is shown by the diagram of a car on a tangent and on a 10° curve, and presumably these dimensions have been adopted with a view to the future construction of a permanent lining inside the timbering. The area of the tunnel, measured above the grade line and 6 ins. outside of the 10 x 14-in. main timbers, is such as to give 17.25 cu. yds. of excavation per lin. ft.

THE OFFICIAL REPORT ON THE RAILWAY ACCIDENT AT SALISBURY, ENGLAND, ON JULY 1, 1906.

We have recently discussed the need of expert investigation into the causes of railway accidents in this country, and have pointed out the merits of the system obtaining in England, where all such accidents are investigated and reported upon by inspecting engineers of the Board of Trade, which is a government department. In our issue of November 22 we gave the report made upon an electric railway accident in London. Below we give a full abstract of the report made by Major Pringle, one of the government inspectors, upon the terrible derailment accident on the London & Southwestern Railway, at Salisbury, on July 1, in which a number of American passengers just landed from the steamer "New York" were killed. This accident was discussed editorially in our issue of Aug. 9.

The report given below was accompanied by track plans, drawings of the engine, copies of the various orders to enginemen relative to this train, and also copies of the signalmen's records showing the times at which the train had passed various points. We would call attention specially to the wide scope of the inquiry and the careful consideration of the various conditions bearing upon the case. These include the composition and weight of the train, the speed throughout the run and at the time of the accident, the character of the track, the character of the damage to the track and the train, the personal character of the engineman and the time he had been on duty, and also the rules and regulations of the different departments as affecting the running of this train. All these were investigated and reviewed. It will be noted that Major Pringle expresses the opinion that the engine did not "jump the track," but overturned sideways. This was due to the excessive speed of the train in passing around a sharp curve, at 65 or 70 miles an hour; although the schedule provided for a speed of about 30 miles an hour through the station on account of this curve. Attention may also be called to the fact that stress is laid upon the desirability of cooperation between the engineering, mechanical and operating departments of a railway in order to ensure safety in service.

I have the honor to report, for the information of the Board of Trade, the result of my inquiry into the circumstances attending the disastrous accident to a passenger train, which occurred about 1.57 a. m. on July 1, at Salisbury Station on the London & Southwestern Ry. In this case the weekly boat express train, from Plymouth to London, was traveling through the station on the up through line, when the engine and coaches left the rails and came into violent contact with a milk train, which was moving in the opposite direction on the down through line. The engine and train wreckage also struck a light engine which was standing in the down bay platform road.

The express was hauled by a four-wheels-coupled engine with leading bogie (2-4-0) of the company's ordinary express type, having attached an eight-wheeled tender. The coaching stock comprised five vehicles.

The train was equipped with the vacuum continuous brake, worked from the engine, with blocks on the four engine driving wheels, and on all wheels of the tender and coaching stock. There was the usual hand control on the wheel blocks of the two brake vans. Control over the continuous power brake was also provided in the brake vans by means of the usual guard's valve attachment. The brake arrangements generally appear to have been in good working order. The down milk train was drawn by a four-wheels-coupled engine, and comprised twenty-one brake and milk vans.

The three leading vehicles of the express were overturned in various directions, the frames stripped of woodwork and completely destroyed. The fourth vehicle fared little better, as one end and the whole of one side of the woodwork was torn out. Comparatively little damage was done to the last vehicle, which came to rest in an upright position with the last pair of wheels on the proper rails. The engine and tender were both overturned on their right sides, but less damage was done to them than would be expected, and the engine was shortly afterwards hauled from Salisbury into the Nine Elms Works on its own wheels. Five vans of the milk train—Nos. 13 to 17 from the front—were completely destroyed, and five others damaged.

The damage to the permanent way of the up through line was surprisingly small, but a length of about 40 yds. of the down line was torn out and destroyed.

The approach to the station from east and west is by two lines of way only, for up and down traffic

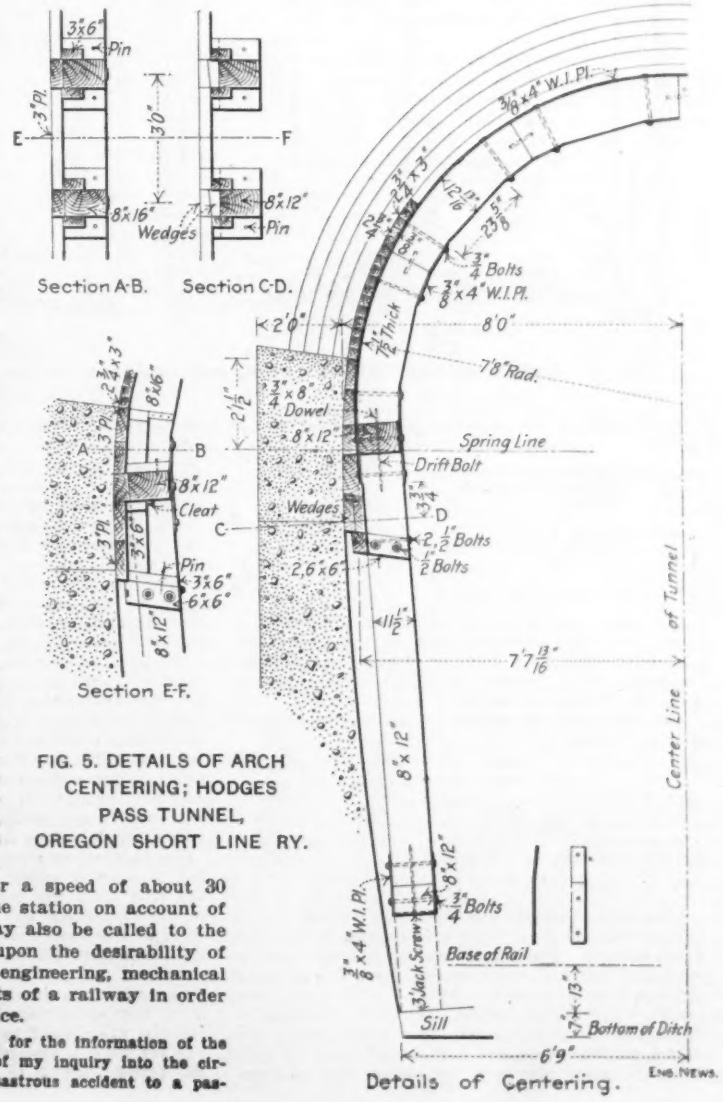


FIG. 5. DETAILS OF ARCH CENTERING; HODGES PASS TUNNEL, OREGON SHORT LINE RY.

respectively. These lines each divide into a pair of lines, so that through the center of the yard there are four through roads serving three platforms. The pair of loop lines on the north side of the central, or island, platform are used for up local and up through traffic. The pair on the south are similarly used for down traffic. The working of the yard is controlled from two signal-boxes known as Salisbury East and West.

The boat express train approached Salisbury from the west on the up road, and traveled through the station on the up through line. There is a left-hand curve at each end of the island platform on the up through line. The curve at the west end of the platform has a radius of 18 chains; that on the east, where the accident took place, was originally laid out with a radius of 10 chains. Immediately east of Fisherton-street Bridge, the up through line unites with the up local line by means of a crossing junction. The reverse curves of the junction have radii of about 7½ chains. The next signal-box east of Salisbury East is known as Tunnel Junction, and is distant about 1,520 yards.

As regards gradients through the station yard, from Salisbury West box the line falls at an inclination of 1 in 520; then it rises at an inclination of 1 in 547, and then there is a sharper rise of 1 in 158 to provide headway at the bridge over Fisherton street. In the last 1½ miles before Salisbury West box is reached, the gradients fall at inclinations of 1 in 115 to 1 in 183.

The train service commenced on April 9, 1904, and has been worked, with but two or three exceptions, regularly since that date. Prior to the commencement of this service all the company's trains were booked to stop at Salisbury Station; the speed approaching and leaving the platforms was therefore necessarily low. It was arranged that the boat express should not call at any station between Devonport and London, but that one stop should be made at Templecombe Junction for the purpose of changing engines. An abstract of the running times and average speeds is as follows:

	Time allowed	Average speed per hour.
Devonport to Templecombe, 117½ miles	2 hrs. 21 min.	50 miles
Templecombe to Waterloo, 112 miles	1 hr. 56 min.	57.9 miles

No trial trip was run for the new service, as the skeleton time-table was practically based upon the timings of the ordinary express trains. These had been accelerated about a year previously, and a trial trip was run in connection with this acceleration. But representatives of the running and traffic branches accompanied the first journey made by the boat express on April 9, 1904. It was then apparently recognized that high speed through Salisbury Station was inadvisable. A notice was issued to enginemen by the chief mechanical engineer on April 20, 1904, limiting the speed of non-stopping trains through Salisbury to a maximum of 30 miles an hour. A second special specific timing for the boat express at Salisbury East signal-box is omitted, two minutes are still allowed for running between Salisbury West box and Tunnel Junction. The distance between these points being 2,774 yds., the average speed therefore indicated by the latest issue of the working time-tables is 38.7 miles an hour. This is not at variance with the speed restriction of 30 miles an hour through the station, or with the one-minute timing between the East and West boxes.

Two further notices issued to enginemen by the Mechanical Engineer's Department are dated May 3 and June 14, 1904, respectively. Mr. French explains in his evidence that these notices were issued on account of reports which had reached them of enginemen, with the boat express, running at higher speeds than those scheduled, on sections of the railway in the vicinity of Basingstoke. Since the date of this last notice, no reports appear to have been received of enginemen exceeding the scheduled speeds with this express.

The evidence and documents mentioned establish clearly these points. First, there has been no acceleration of the boat express over the whole journey since the initiation of the service in April, 1904. Secondly, there has been a regulation in force since April 20, 1904, restricting the speed of all non-stopping trains through Salisbury Station to a maximum of 30 miles an hour. Thirdly, action has been taken in various ways by different departments during the past two years to prevent enginemen from running at speeds beyond those

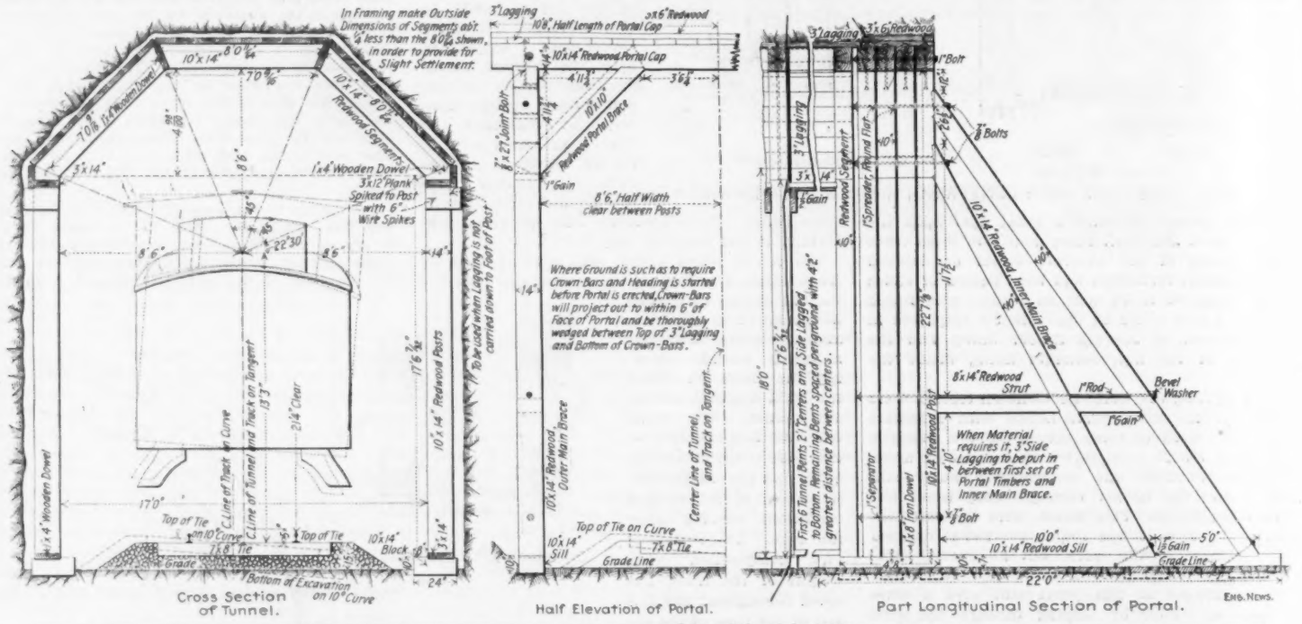

In Framing make Outside Dimensions of Segments abt. ¼ less than the 8'0½" shown, in order to provide for Slight Settlement.
3"Lagging
3"x6"Redwood
10'8" Half Length of Portal Cap
10"x14" Redwood Portal Cap
10"x14" Redwood Segments
1"x4" Wooden Dowel
3"x12" Plank Spiked to Post with 6" Wire Spikes
8'6" Half Width clear between Posts
Where Ground is such as to require Crown-Bars and Heading is started before Portal is erected, Crown-Bars will project out to within 6" of Face of Portal and be thoroughly wedged between Top of 3" Lagging and Bottom of Crown-Bars.
To be used when Lagging is not carried down to Foot of Post
10"x14" Redwood Posts
10"x14" Redwood Outer Main Brace
Center Line of Tunnel and Track on Tangent
Top of Tie on Curve
10"x14" Sill
7"x8" Tie
Grade Line
Bottom of Excavation on 10° Curve
Cross Section of Tunnel.
Half Elevation of Portal.
1"Bolt
1"Bolts
Redwood Segment
1"Spreader, Round Flat
10"x14" Redwood Inner Main Brace
8"x14" Redwood Strut
1"Rod
Bevel Washer
1"Gain
When Material requires it, 3" Side Lagging to be put in between first set of Portal Timbers and Inner Main Brace.
1"Serewrter
1"Bolt
10'0"
10"x14" Redwood Sill
Part Longitudinal Section of Portal.
Eng. News.

FIG. 6. TIMBERING FOR TUNNEL LINING AND PORTALS ON THE RECONSTRUCTION OF THE SOUTHERN PACIFIC RY. BETWEEN OGDEN, UTAH, AND RENO, NEV.

The weight of the engine in working order was as follows:

	Tons cwt.	Tons cwt.
Engine—leading bogie	16 17	
" leading driving axle	19 2	
" trailing	18 0	
		53 19
Tender—leading bogie	23 2	
" trailing bogie	21 15	
		44 17
Total, engine and tender		98 16

The length over buffers of engine and tender is 57 ft. 5 in.; the driving wheel base is 10 ft., and the diameter of driving wheels is 6 ft. 7 in. The engine has inside cylinders, 19 in. diameter by 26 in. stroke; working pressure, 175 lbs. per sq. in.

The dimensions and weights of the coaching vehicles were as follows:

	Length over frames. Feet.	Weight unloaded. Tons.
No. 17.—Brake van	44	19¼
No. 47.—First-class saloon	47½	23½
No. 58.—First-class saloon	47½	23½
No. 84.—First-class saloon	47½	23½
No. 492.—Kitchen car and van	48	23¼
Total		113

Allowing for baggage and passengers, it may be assumed that the total weight behind the tender was about 120 tons. Over buffers the length of the coaching stock was 252½ ft., and inclusive of engine and tender the length of the train was 309 ft. 7 in. over all. The carriages were of the corridor type, with gangways between the last four vehicles. The (truck) wheel base of the carriage stock was 8 ft. Compressed oil gas—Pintsch's system—was used for lighting the carriages.

The traffic notice, dated April 21, 1904, was issued for the second occasion on which this express was worked. From the enlarged time-table in this notice it will be seen that the restriction of speed to 30 miles an hour through Salisbury is specifically mentioned. More sectional timings are given in this notice, but the total running times are identical with those given in the first notice.

After this the service was worked regularly, and no alteration was made in the skeleton time-table until Feb. 10, 1906. A third special traffic notice was issued on this date. In this notice an additional minute is allowed in the running time between Devonport and Salisbury, and an interval of one minute is allowed for running between Salisbury West and East signal-boxes. The distance between these boxes being 755 yds., the average speed indicated by the new timing is therefor between 25 and 26 miles an hour. Mr. Holmes explains in his evidence that the revised timing between Salisbury signal-boxes was made in consequence of a complaint he had received from the engineering branch that a private special train had exceeded the maximum speed limit of 30 miles an hour through the station. His intention in putting in a timing between the West and East boxes was that a reasonable margin of time should be allowed for considerable slackening of the speed of the train through the station. The extra two minutes is allowed in this third notice as far as Basingstoke, but the total time for the whole journey—i. e., 4 hrs. 20 mins.—remained unaltered, as the time originally allowed between Basingstoke and Hampton Court Junction was reduced by two minutes.

In the working time-tables issued by the company for the period June 1 to Sept. 30, 1906, although the authorized by thi sspecific restriction and the scheduled timing of the train.

Accounts of the journey of the train, on the night in question, are to be found in the evidence of Driver Lailey and Guard Harrison. The train comprised an engine and tender of the usual 2-4-0 express type, weighing 98 tons 16 cwt., and five bogie coaching vehicles. The latter weighed with passengers, luggage, etc., possibly 120 tons. Five bogie vehicles is the maximum load with a single engine for this boat express. Lailey—on engine No. 288—drove the train from Devonport to Templecombe. He proves that the continuous brake was in good order and was effectively used on this half of the journey. Both Lailey and Harrison declare that the train ran as usual to Templecombe, where it arrived one minute before time.

At Templecombe Driver Robins and Fireman Gadd—with engine No. 421—relieved Lailey. It was Gadd's duty to couple the engine and tender to the train, and connect the brake hose. Harrison, who rode in the kitchen van at the end of the train, did not, as was his duty, prove the continuity of the vacuum brake, by reducing the pressure of the vacuum in his gage before the train left Templecombe. But he asserts that he saw the pressure rise in his gage, after the engine was attached, and was satisfied that the brake was in working order. The train waited at Templecombe four minutes, and left at booked time.

In accordance with the times entered in the signalmen's books, it appears that the express was never more than two minutes behind time on the first half of the journey to Templecombe, or more than one minute before time. After leaving Templecombe, on time, the train lost four minutes in the first 20 miles to

Dinton, and gained two minutes on the time-table in running the distance of eight miles between Dinton and Salisbury West. Three and a half minutes were allowed for running between Wilton and Salisbury West, the distance being 2.31 miles, and only two minutes were actually occupied. The table shows the average speed for the train between Dinton and Wilton to have been 70 miles, and between Wilton and Salisbury West 69.1 miles per hour.

It is, of course, obvious that these figures must be regarded with all the reserve due to the fact that the timings entered in their train books by signalmen show minutes or half-minutes only. The speeds and times calculated therefrom cannot be regarded therefore as more than approximations. On the other hand, it is not always remembered that there is as much likelihood of errors occurring from over-estimation as from under-estimation of time by the signalmen. So that, after all, the time occupied may have been shorter, and the average speeds higher than those given in the table.

Guard Harrison states that his impression was that the train was a little behind time at Salisbury West box to the extent of about a minute. It was his experience, he says, since February last, for drivers of this train to apply the continuous brake near the Salisbury West box, and for the speed of the train to be reduced to about 30 miles an hour at the west end of the platforms. On this night the brake was not so applied by driver Robins. Harrison tried first of all to draw the attention of the driver, as they were passing the West box, by using his hand brake. Immediately afterwards, as there was still no movement of the needle gage of the continuous brake in his van, he himself applied the continuous brake gently, again with the object of reminding the driver of the speed of the train, and of the necessity for a reduction of speed. The application, however, did not have the desired effect, and was not forcible enough in itself to reduce the speed of the train. It was manifestly a very gentle application, if, as Harrison states, he saw the needle of the gage immediately resume its original position. The vacuum could certainly not therefore have been reduced by 10 ins., as mentioned by Harrison. All this, of course, took place in a very short period of time, and before anything else could be done, Harrison was thrown across the van by the shock of the collision. He estimates the speed of the train at the west end of the station at 50 or 60 miles an hour, and states that he thought the speed was unsafe, if the brakes were not applied.

The evidence of signalman Mundy, stationed at Salisbury West signal-box, is valuable. It confirms the statement of guard Harrison that, contrary to usual practice, there was no slackening of the express as it passed his box, and that the continuous brake was not in operation on the train. He estimates the speed of the train as it passed his box at about 60 miles an hour. This was very much higher than the usual speed of the train, which would be about 35 miles an hour. He thought at the time that the speed was dangerous for the curves at the west end of the station. Steam was shut off as the train passed him, and the engine whistle was sounded as the train ran by his up-distant signal.

Inspector Spicer, foreman Rook, and carriage examiner Abbott confirm the statement that the train passed the platform at Salisbury at a higher speed than usual.

The evidence of signalman Haines at Salisbury East is also of importance. It fixes the time at which the train passed the West box as something over 1.56½ a. m. This corresponds with signalman Mundy's time—as corrected by Mr. West—and confirms with some accuracy the actual time fixed by inspector Spicer of the accident as 1.57 a. m. The average speed of the train between Dinton and the scene of the accident, a distance of 8.4 miles, works out from this additional data at about 72 miles an hour, an average higher than that shown on the table.

Mr. French proves that, after the accident, an examination of engine No. 421 showed that the regulator (throttle.—Ed.) was closed, the motion gear was nearly in the full forward position, and the driver's vacuum brake handle was in the neutral, or running position. This is confirmatory of other evidence showing that the engine was not steaming, but running free, and that the continuous brake was not applied. The very complete destruction of the three carriages behind the engine, and of five vehicles of the milk train, proves the enormous amount of energy in the train at the time of the accident.

I consider all this evidence most conclusively proves that the boat express was traveling at a very high rate through the station. It is, of course, impossible to say what the speed of the train actually was. But the whole of the evidence points to the probability that the speed was at least twice as great as that authorized by the company in their speed restriction, and it is possible that it may have been as much as 70 miles an hour, as stated by Mr. Herbert Brookman, one of the passengers, in his evidence.

This was the first occasion on which Robins had driven the boat express, and probably the first time he was required to run through Salisbury Station without stopping. He was forty years old, had altogether 22 years' service with the company, and had driven between London and Exeter during the last eight years. He was a fully qualified express driver, and, as such, took his turn with other men of the same standing for working this train. He was a total abstainer, and bore a fair character. It is given in evidence by Inspector Furze and shunter Mullett, who saw and spoke to Robins at Templecombe, the former about 1½ hours, and the latter about half-an-hour before the express arrived, that he was perfectly sober and fit for duty. Mullett states that Robins said he had no intention of getting into Waterloo before time, otherwise he would be found fault with by the chief mechanical engineer. Robins signed the several notices, printed in Appendix II., which were issued by his own and the Traffic Department, regarding the restriction of speed through Salisbury Station and the one-minute timing between the West and East boxes. The undermentioned general rules were also applicable:

No. 136. The engine-driver and fireman, before commencing duty, must ascertain from the notices posted for their guidance if there be anything requiring their special attention on those parts of the line over which they have to work.

No. 148 (A). Engine-drivers of trains, when running through junctions to or from lines diverging from the straight road, must so reduce their speed as to ensure a steady passage for the whole train through the junction points and crossings.

Apart from regulations and timings, it is inexplicable how a driver with the experience of Robins could have been apparently so reckless as to travel at such a high speed on this section of the line. The fact that the engine whistle was sounded as the train approached Salisbury West box appears to show that he was alert and knew his whereabouts. It might perhaps be possible that, never having previously passed through the station without stopping, a driver might not have recognized the short curve, on which the disaster occurred, as one unsuited for high speed. But 20 yds. in advance of where the engine was found overturned there are facing points on the up through line leading through an ordinary scissors crossing on to the up main line. The reverse curves of this crossing have radii of about 7½ chains. The train had to travel over this junction crossing, and I think no driver could fail to recognize such a crossing as dangerous for any but very moderate speeds.

The statements of express drivers Mercer and Trimmer, who have frequently driven the boat express between Templecombe and London, are of interest, as showing what their custom has been as regards the application of the continuous brake, and the rate of speed through the station. It does not appear from their account that any difficulty has been experienced in maintaining the scheduled timings for the train with a load of five bogie cars. These men, as well as Lailey, give it as their opinion that an express driver, even on the first occasion of his running through Salisbury without stopping, would recognize that it was necessary to slacken speed at the east end of the station, on account of the sharp curves. The evidence shows that the regulator (throttle) was closed when the train was passing through the station. To this extent Robins appears, therefore, to have complied with the speed restriction. But merely closing the regulator, without any application of the continuous brake, was not likely on such easy gradients to have materially reduced the high speed at which the train was traveling before the curve was reached where the accident happened. Robins appears to have been on duty for 9½ hours at the time of the accident.

It has been stated that the engine-men with this boat express have been encouraged, by receipt of tips from passengers, to run at excessive speed. I have gone thoroughly into this question, but have not obtained any evidence in support of the statement, which appears to be quite unwarranted. The evidence shows that the passengers had no opportunity of speaking to either of the drivers employed except on arrival at Waterloo (London).

The left-hand curve, on which the accident took place, commences immediately at the eastern termination of the island platform. It has a total length of about 92 yards. The radius of the curve appears to have varied from about 12 chains or more at either end to 8 chains over the greater part of its length. Except for a rail length (30 ft.) at either end, the curve is checked throughout. The check rail from its appearance had clearly been doing its work well. The rails are level at the west tangent point. At distances of 10 and 20 yards respectively from the west tangent point the outer rail has an elevation of 1¼ in. and 3½ in. above the inner rail. This superelevation of 3½ in. was maintained for a distance of about 15 yards. It then decreased gradually until opposite the eastern end of the check rail, where it amounted to 2⅛ in.

The damage which was found to have been caused to the permanent way of the up through line is very slight, and altogether different from what would be expected to result from an ordinary derailment at high speed. The track was not slewed nor the rails burst. Neither the outer rail nor the check rail showed marks such as would be made by the flanges of engine wheels crossing them. On the check rail especially, which was covered with the usual dirt and grease, such marks would have been easily visible. There were no marks on the sleepers in the four-foot or six-foot ways, such as would be made by a pair of wheels. None of the inside jaws of the chairs under the inner or check rails were broken. Nearly the whole of the damage done to the chairs under the outer rail was evidently caused by coach wheels riding outside the rail, which was driven inwards over a considerable length of the curve, to a total extent of about ⅞ in., including the original slack. The wrought-iron chair spikes showed a corresponding twist. The only rail broken in the up through line immediately adjoined Fisherton St. bridge. It was broken inwards, evidently by one or other of the three leading coaches, two of which crossed the line and the third lay across it.

The greatest damage was done to the down through line. A length of about 40 yds. of this road, westward of Fisherton St. bridge, was completely destroyed. A big trench, 3½ ft. in depth, was scored through the ballast and formation. The center line of this trench corresponded roughly with the proper position of the northern rail of the down line. I could find no evidence, from the condition of the permanent way after the accident, to show that the engine mounted or jumped the rails, or that the track had been slewed or the rails burst. The permanent way generally was stiff and in good condition.

I examined carefully the engine and tender, both at Salisbury and after their arrival in the Nine Elms Works. The engine had only been in service since August, 1905. There was no hollowness of tires or sharpness of flanges. Both tires and flanges were in thoroughly good condition. There were no marks on the flanges of the leading bogie such as would be occasioned by the wheels meeting with an obstacle on the road, or mounting the rails. The right-hand wheels of both engine and tender showed signs of having ploughed into the ground. Soil was caked into the angles and crevices of the spokes. But there were no such indications to be found on any of the left-hand wheels. All the axles on the train were found unbroken after the accident.

It has been suggested that the engine bogie seized or jammed, and thereby derailed the engine. I do not think this was possible with the clearance of one-eighth of an inch which had been provided for the bogie pin. And even if possible, the results, especially on the permanent way, of a derailment of this description would have been altogether different, in my opinion, from those in this case.

From calculations made by the company's chief mechanical engineer, it appears that the center of gravity of engine No. 421 was about 5 ft., and of the tender 4¾ ft., above rail level. Any calculation for determining the center of gravity of an engine or vehicle is necessarily complicated, and the result can only be accepted as an approximation. Compared with the height of the center of gravity of modern express engines as assumed in text-books, a greater height than 5 ft. would, I think, be generally expected for an engine of the type of No. 421, with a boiler center 8½ ft. above rail level. But it can be shown by well-known and accepted formulae that, on a curve with a radius of 8 chains (= 10.8 deg.), a vehicle with a center of gravity 5 ft. above the rails is in unstable equilibrium at a speed of about 67 to 68 miles an hour, even when the full allowance is made for the beneficial effect of 3½ in. of superelevation. In the case of this particular curve there was no superelevation at the tangent point, and over the greater portion of the curve the superelevation was less than 3½ in. Moreover, it is probable that the effect of centrifugal force would have so acted on the springs, whilst the vehicle was still in a state of stable equilibrium, as to bring the center of gravity into the position it would occupy if the vehicle were a rigid body, and there was no superelevation. Unless there is a gradual lead into a sharp curve of this description, the effect of sudden impact has also to be taken into consideration. It is in accordance with the views of well-known writers to make some allowance for effect of impact, in determining the speed at which overturning due to centrifugal force on a sharp curve becomes imminent. Some disregard the beneficial effect of superelevation, others make a very much greater allowance, by doubling the amount of centrifugal force. In this particular instance, if the small amount of superelevation is not taken into account, a calculation, or diagram of forces, will show that for the engine and tender, taking the centers of gravity as 5 ft. and 4¾ ft. above rail level respectively, overturning is imminent on a curve with a radius of 8 chains at speeds of about 63 and 65 miles an hour.

Bearing this in mind, and for want of any evidence from the condition of the permanent way, engine wheels, etc., of ordinary derailment, I have come to the conclusion that the high speed at which the train was traveling caused the engine to overturn on the sharp curve immediately at the east end of Salisbury Station platform, and that the disaster was directly caused by the speed of the train, which must have been very much in excess of the maximum speed authorized by the company's instructions and timings. It is obvious that no increase in the depth of the flanges would have any effect in minimizing liability to overturning.

I do not think that there was any defect in the permanent way, or in the engine or rolling stock, which was likely to have contributed to the accident. Nor had the length of the train, or the weight of the load behind the engine, anything to do with the case. Further, I believe that, if the speed limit of 30 miles an hour through the station had not been exceeded, the disaster would not have occurred.

The bulk of the damage to the first three coaches was, in my opinion, caused by their heeling over and dashing at high speed against the upturned wheels of the tender. The wheels of the tender seem to have torn the sides out of these coaches, and I do not believe that any stiffening of the bodies of the coaches would have had much effect in lessening the destruction.

The maximum amount of superelevation used on the company's system is 6 in. Even had this amount of superelevation been provided on this curve, it would not have prevented a catastrophe occurring at such a high speed. For if by a miracle the train had kept the rails on the curve where overturning took place, it must have been derailed or overturned with equally terrible results on the still sharper reverse curves at the junction crossing immediately east of Fisherton St. Bridge. Here there was no superelevation provided, and it was not possible to provide any.

It was within the power of Guard Harrison, if he was aware that the train was not running in accordance with usual practice, or with the company's speed limit and timings, to apply the continuous brake himself. If he had done this, he would have reduced the speed of the train, and possibly prevented the accident. He explains that he was afraid of breaking couplings, or causing some other damage to the train. He stated at my inquiry that he recognized that the speed was dangerous, and if this were so, it was his duty to have used the brake, even at other minor risk. In his evidence at the Coroner's inquest, he said he did not think the speed was dangerous, and made other statements conflicting with the evidence he gave before me. I feel obliged, therefore, to regard with suspicion much of the material portion of his statement. Whilst recognizing that his position was a difficult one, it was a matter for regret that he showed himself so little fitted for responsibility, when he must have been aware, if he was awake and alert, that the driver was not obeying the company's instructions regarding speed.

There are some other points to which it appears necessary to call attention.

It is not in accordance with general practice on English railways for speed restrictions on account of permanent way to be imposed by the running department. Nor does it appear that that department is best qualified for deciding such questions. The engineering staff alone possess information regarding details and condition of track upon which limits of speed are mainly based. Upon the engineering staff should fall the duty of fixing the restrictions necessary for safety. Wherever any portion of the track is unsuited for express speed, the responsibility should be laid upon the engineer of declaring the fact, and of imposing a speed limit. This should be done irrespective of whether express traffic is worked over the particular section of road or not. These speed limits should be printed together in the company's working time-tables, or other periodical publication, and all departments of the service should co-operate in upholding them. A want of co-operation inevitably tends to lower the standard of security on a railway.

The question of proper speed limits is a complex one. A wide margin on the side of safety is expected and allowed for on British railways. It is well also to consider the desirability of providing comfort as well as safety in traveling. In the case of a sharp curve, the point of danger is reached long before there is theoretically any imminence of overturning. But there is also risk of serious oscillation, severe impact, etc., which will cause apprehension of danger and discomfort long before the actual point of danger is attained. Allowance has also to be made for the difficulty of accurately gaging speed.

As regards the curve at the west end of Salisbury Station, a maximum speed limit of 30 miles an hour, provided that the required superelevation is supplied, meets both the requirements of safety and comfort; but for the curves at the east end the case is different. A speed of 30 miles an hour is outside the limits of danger if the permanent way is stiff and in good order, as in this case; but such a speed would require the maximum superelevation shown in the engineer's tables, and this would have to be provided all through the first curve. The circumstances do not appear to permit of this provision. Without this superelevation a speed of 30 miles an hour would mean discomfort in traveling, and possibly cause alarm in the minds of passengers. There is also the junction crossing, with reverse curves of 7½ chains radius, which commences on the east side of Fisherton St. Bridge, to be considered. Here no superelevation to speak of can be given. I do not think, therefore, that it would be wise to allow a higher speed than 15 miles an hour on the curves at the east end of the station.*

Railway companies have to contend with many difficulties which are the natural result of their lines having been laid out in early days before experience was gained, and when high speeds were never contemplated. Many improvements have been carried out in the perfecting of the permanent way, rolling stock, signaling, etc., in order to enable traffic to be worked safely at express speeds. But further improvements in the way of alinement and inclination will assuredly become necessary if companies desire to place themselves in a position to meet a demand for long-sustained high-speed traveling. This condition is one which has to be faced.

THE NEW COAL HANDLING AND STORAGE PLANT OF THE ERIE RAILROAD.

A large coal handling and storage plant has recently been constructed by the Erie Railroad Co. at its yards in East Buffalo for the sizing, blending, screening and storing of anthracite coal for Western trade. Figs. 1 and 2 show the entire plant, Fig. 1 illustrating the storage building and Fig. 2 the screening house.

The storage building is the largest covered coal storage plant in the United States. It is 550 ft. long, 72 ft. wide, has a capacity of over 25,000 tons, and is of steel construction supported on concrete piers. The coal, however, rests entirely on hard wood laid over the ground, which is cut out at an angle of 40°. A plan and a section of the storage building are given in Fig. 3.

Coal is brought to the plant directly from the mines and is discharged through four track hoppers and gates to a 30-in. belt conveyor, 166 ft. between centers, which is driven by a 20-HP. motor. This conveyor delivers to either or both of two belt conveyors running at right angles to it. One of these conveyors takes the coal directly to the screening house, where it is screened and delivered to any one of the five bunkers provided, each of which has a capacity of 60 tons. From the bunker the coal is delivered to the cars.

The screens used are 5 ft. wide and 20 ft. long, and have perforations of such sizes as to sort the coal into what is commercially known as egg, stove, nut, pea and screenings. A separate bin is provided for each of these sizes, and the bins are so designed that cars may be loaded from either side of the house. The screens are four in number, driven by one 10-HP. 220-volt a. c. motor.

When coal is taken from the transfer point to storage, a third belt conveyor, 612 ft. long, driven by a 40-HP. motor, is used. This conveyor is equipped with a Robins automatic self-reversing tripper furnished with a special chute which discharges to storage. This chute and conveyor are shown in Fig. 4.

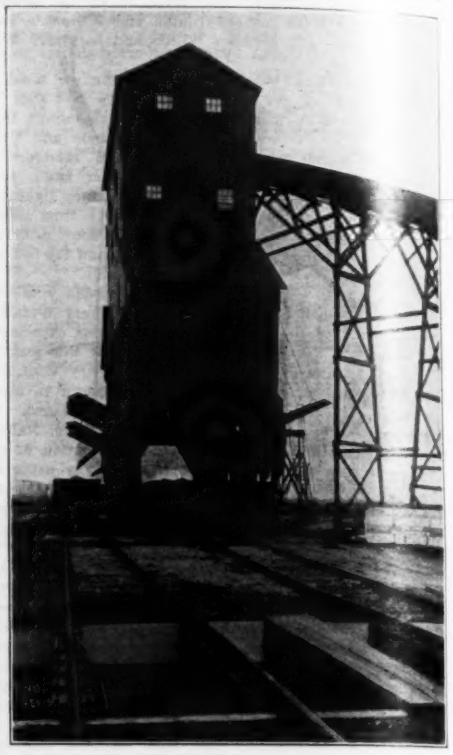


Fig. 2. The Screening House Used in Connection with the Storage Building Shown in Fig. 1.

When coal is taken from storage, gates in the roof of a tunnel underneath the storage are opened and the coal is delivered to a conveyor running in the tunnel through a traveling hopper. This reclaiming conveyor is 612 ft. long, and is driven by a 40-HP. motor at its discharge end. It delivers the coal to the conveyor which takes the material to the screening house.

By means of the conveyor system installed,

FIG. 1. THE NEW 25,000-TON COAL STORAGE BUILDING OF THE ERIE RAILWAY AT BUFFALO.
This is the largest covered storage plant in the United States.

*It is for consideration whether it would not be advisable for the distant signals at each end of the Salisbury Yard to be held at danger, with the object of emphasizing the speed limits.

coal can be taken from cars and screened or it can be taken from cars and stored; it can be taken from cars and by splitting the stream screened and stored at the same time. Coal can also be taken from the cars and from storage and screened at the same time, or it can be put into storage and taken from storage at the same time.

The Robins Conveying Belt Co., of New York, furnished the conveying and screening machinery and also designed the entire plant. We are indebted to them for the illustrations and descriptive matter relating to the plant here given.

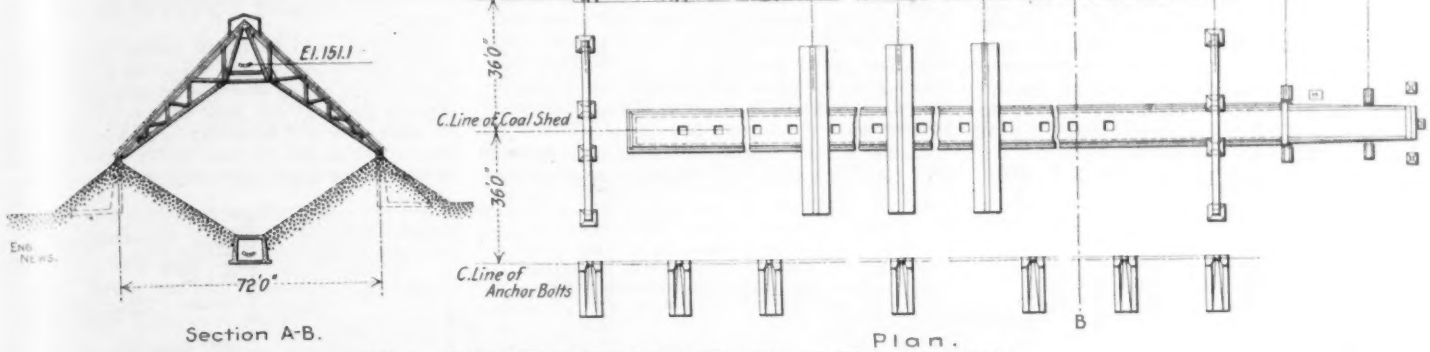


FIG. 3. PLAN AND SECTION OF THE COAL STORAGE BUILDING.

BRICK PAVING AT CANTON, O.

The subject of brick paving, and the experience with it under different methods and conditions, is one of particular interest to municipal engineers, and we have recently published a considerable amount of information on this subject. In the annual report of the Ohio Engineering Society we find an interesting paper on the experience with brick paving for streets and street car tracks at Canton, O., by Mr. F. E. Myers, City Engineer, and from this we take the following extracts:

The first active work of paving began in 1890 in which year over 52,000 sq. yds. were laid, ranging in price from $3.56 to $4.26 per front foot. This work was all laid upon 8 ins. of gravel and sand for foundation and with tar as a filler, and all but about 9,000 sq. yds. was of standard shale paving brick, the remainder being standard fireclay paving brick. The foundation was prepared after the usual manner of grading out to the required depth, then rolling the subgrade well with a 10-ton steam roller, after which the stone, gravel or sand foundation was put in place and well rolled. Upon this was placed the sand cushion, usually of 2 ins., which was sometimes looped out and sometimes scraped into form. At present we use a former entirely except at intersections, corners, etc. We have a total of 333,265 sq. yds., or about 20 miles of street with an average roadway of 30 ft. In this work there have been used three different kinds of foundation. The first was of gravel and sand. Later there was a part of one street laid upon a concrete foundation; still later there were several parts of streets laid with broken stone foundation. Upon these different kinds of foundations have been laid standard brick of shale and fireclay, shale block, both wire cut and repressed. The block are in size 3½ × 4 × 8½ ins. Of the two kinds we are getting the greater service from the shale product, the other in one street having worn in the center until the brick are not more than two inches thick.

Of the various kinds of fillers, we used tar until 1896, when the first street was laid with a cement filler. From then until the present time the major part of the work has been laid with cement filler. A few have been laid with a clean sand filler, and a few with a combination of cement and sand, the gutters being cemented for a distance of about 6 ft. out from curb, the balance was filled with sand. Some will say that tar is not a good and durable filler. It softens and runs to the gutter, and leaves the joints in the crown of the street unprotected. This is true in a street with too great a crown; not necessarily true with a flat crown. Our first streets have stood for 15 years and are in good condition except where they have been ruined by the laying of street railway tracks, sewers, water and gas mains, and they were tar fillers.

Others will claim that cement is not a proper filler, for it makes too hard a street and is too noisy for residence streets, both of which are perhaps worthy arguments, but the cement, like tar, has its place. I should never use it as a filler for a wire-cut block, as has been done on some of our streets, because it does not afford a foothold for teams, becoming very slippery at times, and at all times too much so for general traffic. Neither would I consent to using cement filler entirely as we have done in years past, for it is from these streets that our greatest expense of repair comes. In numerous places they have expanded on hot days until the arch has been forced so high that the brick or block have been thrown clear out of their place, breaking either the joints or brick, or both. I watched a section of one of our streets that expanded until it had raised so that the bottom of the blocks, which are 4 ins. thick, were a little above the tops of those yet in place. So great was the force that a heavy loaded wagon passed over it without breaking the arch. Yet there are persons who will argue that there is no expansion in brick, and will insist upon laying paving without expansion joints, or with so few of them that they work as much harm to the street as they do good. Streets paved in 1901 and 1902 in Canton were laid with cement filler and tar expansion joints. These expansion joints were placed about 30 to 40 ft. apart on a 36-ft. driveway and were composed of two transverse and four longitudinal joints of the thickness of common building lath. That this was not sufficient for the expansion of the street is evidenced by the fact that at every transverse joint the blocks have been forced up until it makes a ridge, and are causing the blocks to become crushed and destroyed for about two or three feet on either side of the expansion joint.

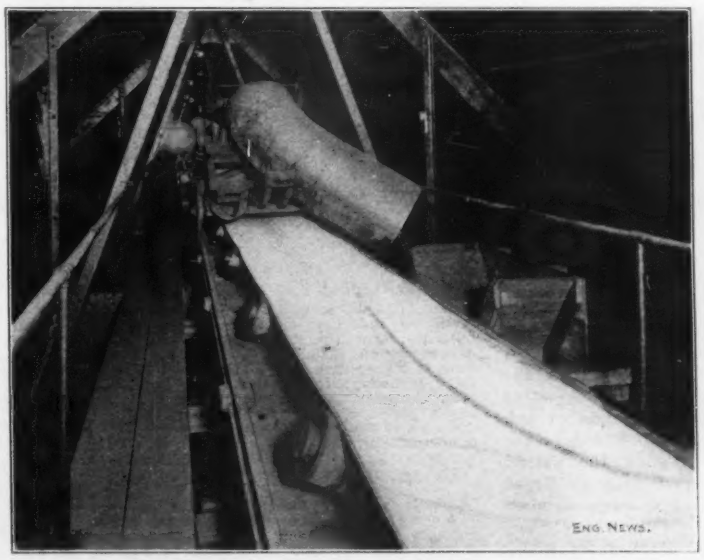


FIG. 4. VIEW NEAR PEAK OF ROOF OF STORAGE BUILDING, SHOWING THE 612-FT. BELT CONVEYOR AND THE CHUTE WHICH DISCHARGES THE COAL TO STORAGE.

In 1903 when the responsibility of the city engineer's office fell to me I insisted upon at least three transverse joints not more than 24 ft. apart and three along each gutter. From this arrangement we have had no difficulty. There has been no bulging at expansion joints or cracking of the paving as was the case in streets with too little or no expansion. Because we have streets in these conditions a great many people condemn the use of cement filler, when it is not the fault of the material, but of the improper use of the same.

I do not approve of a filler of cement and sand upon a gravel foundation, because the sand settles into the gravel while the cement remains practically in its original position, leaving a broken-down condition where the two meet.

Our sand-filled streets are in very good condition, even one that has been in service for 13 years. However, I do not favor this kind of a filler, on account of the opportunity of the bed being destroyed by surface water, and the sanitary condition of such a street is very poor. As to the materials used for expansion joints, we have used two kinds, tar and asphaltum. Tar has been extensively used, more on account of the cheapness than its superiority. We have one street that has been down for about seven years on which asphaltum filler was used for expansion; it seems as pliable as when new and stays in its place better than tar.

As to the construction along street car lines, the franchises do not specify that the paving in and along the lines shall be constructed the same as the balance of the street. About all they do say is that the company shall maintain the paving between and for a distance of 9 ins. outside of either outside rail. The traction companies construct their own tracks and maintain them. The city does, however, let the contracts for the paving of the whole street but the traction companies can even then construct all that part they are compelled to pay for under their franchise and can use such ballast and as small an amount under their ties as they choose, according to a decision in our courts this last year. This suit was brought to compel the Canton-Akron Ry. to lay its tracks to grade with proper ballast. The manner of laying the pavement on the recent streets has been to lay that part between rails to the same height as the top of the rail, and that part outside, with ends of the block butting against the rail. The greater part of the trackage is girder rail, there being I believe but two streets that have tee-rail. To give flange room they bolted wood strips to the inside of the web of the tee-rail. Upon most of the streets with girder rails the brick or blocks between, rails were laid with tops level to the flange of the rail, making not only a disagreeable drop from the top of rail to the pavement, but also causing an injury to the pavement from the constant drop of heavy loaded wheels.

A LARGE IRON-WORKING MILL has been established by the Union Pacific Ry. at Laramie, Wyo., where a rolling-mill has been rebuilt for the manufacture of bar iron, bridge and track material, rail fastenings, tie-plates, etc., in order to utilize to advantage the scrap material accumulating on the company's lines.

SPECIFICATIONS FOR REFUSE DESTRUCTOR, BOROUGH OF RICHMOND, NEW YORK CITY.

The first thorough-going, if not absolutely the first, specifications and call for bids for a refuse destructor designed to produce heat for lighting or power purposes in the United States were issued on Nov. 16, 1906, by Mr. George Cromwell, President of the Borough of Richmond, New York City. As noted briefly in our issue of Nov. 29, the specifications call for general plans for a destructor building and for detailed plans for a destructor and its erection complete. The destructor is to have a capacity of 60 tons (2,000 lbs.) per day, with provision for enlargement to 120 tons. No decision has yet been reached as to the utilization of the heat developed by the destructor, the determination of this point awaiting operation tests to determine what amount of heat is actually available. The specifications for the destructor have been prepared by Mr. J. T. Fetherston, Assoc. M. Am. Soc. C. E., Superintendent of Street Cleaning, Borough of Richmond, under the direction of Mr. Louis L. Tribus, M. Am. Soc. C. E., Consulting Engineer and Acting Commissioner of Public Works of the Borough of Richmond. They are based on an investigation extending over a period of two years, in the course of which exhaustive studies were made of the composition and heat value of the mixed refuse collected by the Borough. During the period named, Mr. Fetherston made a trip to Great Britain and carefully inspected a large number of refuse destructor installations there.

The built-up portions of the Borough of Richmond (Staten Island) have a combined population of about 60,000, nearly equally divided between two refuse collection districts, each about two by four miles in area. In the West New Brighton area, which the proposed destructor is designed to serve, a Dixon garbage furnace has been in use for some years. In the other of the two collection districts, known as the Stapleton, mixed refuse is used for filling low lands. As early as 1903 it was concluded that the only means of disposal suited to topographical and other local conditions was by means of burning the mixed refuse, and as no American crematory promised to give satisfactory results a study of other possibilities was begun. As a result, two refuse destructors of the British type, one for each collection district, were recommended. Before going further, the detailed studies at home and abroad, were already mentioned, were made, and general specifications for a destructor for the West New Brighton district were prepared.

The bids for the proposed refuse destructor will be opened on Dec. 27, 1906. The contractor will be required to complete the destructor within 90 days of the award of the contract, but as the city is to contract separately for the destructor foundations and building it seems likely that a longer time may really be available for the destructor contractor. All plans and specifications of unsuccessful bidders will be returned after the contract is awarded.

No bid will be considered unless accompanied by a certificate signed by the engineer in charge

certifying that (a) the destructor is operated without nuisance; that (b) the temperature of the main flue, or combustion chamber, under ordinary working conditions is higher than 1,250° F.; that (c) heated air is used for combustion; that (d) at least 1 lb. of water has been evaporated per pound of mixed refuse burned, during a period of at least eight consecutive hours, and that (e) the steam power so produced is utilized for municipal purposes.

The specifications also state that their object is

to obtain a refuse destructor or incinerator capable of destroying in a sanitary and economical manner, without nuisance, a collection of city wastes, comprising ashes, garbage and rubbish, by burning the same at high temperatures with incidental utilization of the heat produced in raising steam for power production. No experimental or untried installations will be considered.

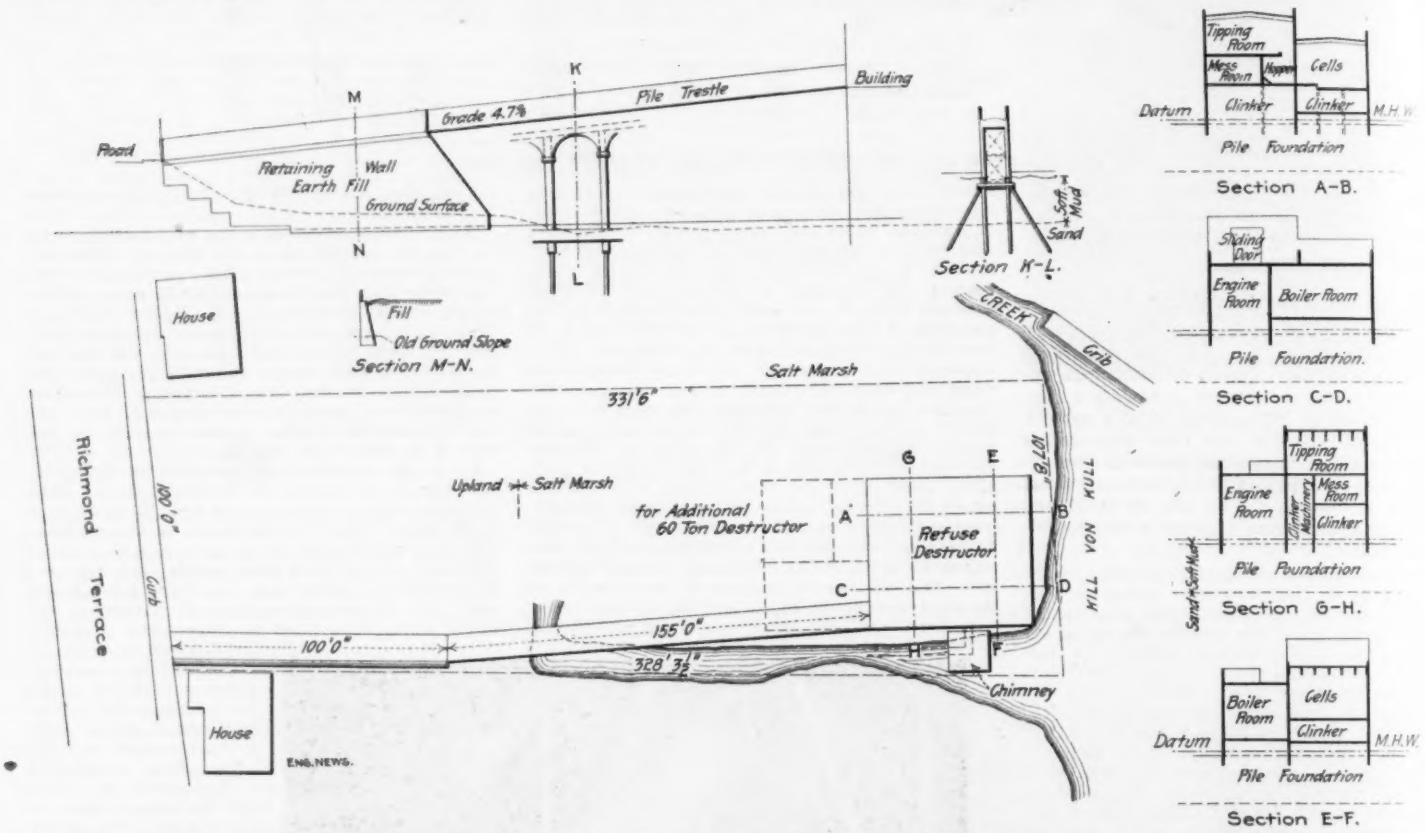
No payment will be made the contractor until after the plant has been completed, tested and accepted, and at that time $1,000 will be retained, to be held for a year in order to make good any defects that have been shown by the destructor.

The destructor will be located at West New Brighton, on a plot of land on the north shore of Staten Island, with a frontage of 100 ft. on Kill von Kull and a depth of about 330 ft. The general location of the destructor buildings, driveway, etc., together with outline plans and cross-sections of the destructor building, are shown by the accompanying illustrations.

The population to be served is approximately 26,000, and is now contributing from 30 to 35 per work day in summer to 50 tons in winter of mixed refuse per day, including some waste from manufacturing establishments. Detailed analyses of the refuse are given below.

It is proposed to use reinforced concrete for the destructor building, foundations, runways, connecting flues and chimney; but the contractor is not required to design the details of the reinforced concrete.

The refuse will be tipped behind closed doors into a 120-cu.-yd. or 60-ton storage hopper from which it will be fed direct to the destructor grates through doors at the back of the cells; that is, the destructor will be of the hand back-feed type. The clinkering will be done at the front and provision will be made for dropping the clinkers to



GENERAL PLAN OF PROPOSED REFUSE DESTRUCTOR SITE AND PLAN AND SECTIONS OF PROPOSED BUILDINGS, BOROUGH OF RICHMOND, NEW YORK CITY.

a lower level and, if practicable, for utilizing the heat given off by the clinkers to raise the temperature of the air used for combustion. The products of combustion will pass through a water-tube boiler at a level lower than the cells. Provision is to be made for a clinker utilization plant, a mess-room and toilet, bath and locker facilities for the firemen. Ample light and air must be provided. The specifications suggest, but do not require

that the air for combustion be drawn through ducts from the upper portions of the cell room and upper portions of the tipping room, thus controlling the flow of dust and smoke, and causing the air from outside the building to rush in, instead of allowing dust or smoke to escape to the outer air.

It is left optional with bidders whether they "arrange a carcass chamber, whereby dead animals could be lowered through a port on the boiler-room deck into a combustion chamber." It is expected that the plant will be operated continuously six days per week, leaving Sundays for cleaning. The contractor is required to furnish

tools for firing, clinkering, barrows for clinker removal, draft gages for recording ash-pit pressures, self-recording steam gage or gages, high-temperature indicators sufficient to last for six tests of eight hours each, a continuous CO_2 recorder of the gravimetric type, low-water indicators or annunciators for boiler, thermometers for recording stack temperature, heated air and atmospheric

temperatures, draft gage for chimney, and such other appurtenances as are necessary to complete the installation, including injectors, feed-water pumps, etc., for the boiler.

Before proceeding with the construction of the destructor (after the general contractor has provided the foundations) the destructor contractor must assure himself of "the sufficiency and strength of the foundation construction," and if not satisfied with it he shall "specify the defects and so notify the superintendent in writing, whereupon the sufficiency of the foundations shall be tested, and their adequacy ascertained."

The balance of the specifications, including notable and useful tables showing the composition of the refuse and the results of calorimeter tests of the various components of the refuse and of evaporative tests of moisture in the garbage, are given in full as follows:

20. GUARANTEES.—The following guarantees are required:

(a) The Contractor shall guarantee that the residue from the furnace under ordinary conditions of operation shall be free of organic matter, thoroughly burned, hard and vitreous.

(b) That no nuisance shall be created in the ordinary operation of plant.

(c) That neither odors, obnoxious gases, nor dust shall escape from the building or chimney.

(d) That at no time during the continuous operation of the plant shall the temperature of the combustion chamber or main flue fall below 1,250° F.

(e) That the flues, dust chambers and boiler setting shall be so arranged that the dust may be withdrawn after one day's cooling of the fires.

(f) The Contractor shall guarantee and specify a minimum or a seasonal rate of evaporation ("from and at" 212° F.), and an amount of net useful steam per pound of refuse burned, either in pounds of steam per pound of refuse or as a percentage of efficiency of boiler and grate per pound of dry refuse, based upon the information given in the paragraph headed "Composition of Refuse."

(g) The Contractor shall state the amount of material to be handled per fireman or stoker employed, per eight-hour shift when high-grade labor is used.

(h) The Contractor shall guarantee to destroy refuse at the rate of 2.5 tons per hour when the material is such as is collected during the winter months shown by the tables in paragraph headed "Composition of Refuse."

The Contractor shall repeat and include the foregoing guarantees as part of his specification accompanying the bid or estimate.

21. TESTS.—Upon the completion of the destructor, and when it is ready for use in burning refuse, the Contractor shall notify the Superintendent thereof, in writing, and as soon thereafter as possible, a test run for a period of not less than two weeks under the joint supervision of the Superintendent and Contractor shall be made to determine the sufficiency of the Contractor's guarantees. During the test run, the quality and quantity of refuse burned shall be varied to represent as closely as possible the seasonal differences in composition, volume and weight of the material, as indicated in the tables under "Composition of Refuse." If it should appear that the destructor is not meeting the requirements specified under "Guarantees," the Contractor shall agree to make any changes necessary to carry out his part of the agreement. Should the Contractor fail in meeting the essential requirements of the "Guarantees" concerning the creation of nuisances due to the operation of the furnace, the City may refuse to accept the destructor; in which event the Contractor must remove from the City's land the destructor and its appurtenances.

22. The following information concerning the local cost of labor and materials is volunteered for the information of the Contractor:

Class of work.	Rate per hour.
Labor	$0.20—$0.25
Carpenter	0.40— 0.50
Bricklayer	0.50— 0.65
Ironworker	0.40— 0.50
Painter	0.40— 0.50
Horse and cart	0.40— 0.45
Team	0.50— 0.65

Kind of material.	Rate.
Spruce lumber, M. ft.	$36.00
Yellow pine lumber, M. ft.	40.00
Sand, cu. yd.	2.00
Portland cement, bbl.	$2.00—2.50
Common brick, M.	8.00—9.00
Broken stone, cu. yd.	1.75—2.00
Building lime, bbl.	1.25

TABLE NO. I.—HOUSEHOLD REFUSE AS COLLECTED, WEST NEW BRIGHTON DISTRICT.

Month.	Ashes and rubbish. Volume. Cu. yds.	Ashes and rubbish. Weight. Tons.	Ashes and rubbish. Per ct. of 12 mos. collection.	Ashes and rubbish. Per ct. of total mont'ly collection.	Garbage. Volume. Cu. yds.	Garbage. Weight. Tons.	Garbage. Per ct. of 12 mos. collection.	Garbage. Per ct. of total mo'thly collection.	Total collection. Volume. Cu. yds.	Total collection. Weight. Tons.	Total collection. Per ct. of 12 mos. collection.
1906.											
January	2,014	962.9	10.6	83.5	409	190.6	5.7	16.5	2,423	1,153.5	9.3
February	1,852	871.5	9.6	87.6	265	123.5	3.7	12.4	2,117	995.0	8.0
March	2,199	1,072.7	11.8	86.0	373	173.8	5.2	14.0	2,572	1,246.5	10.1
April	1,972	973.8	10.7	79.3	545	254.0	7.7	20.7	2,517	1,227.8	9.9
May	1,857	990.4	10.9	78.7	574	267.5	8.1	21.3	2,431	1,257.9	10.2
June	1,725	734.0	8.1	71.9	617	287.5	8.7	28.1	2,342	1,021.5	8.2
July	1,516	426.0	4.7	58.3	653	304.3	9.2	41.7	2,169	730.3	5.9
August	1,661	417.4	4.6	54.3	753	350.9	10.6	45.7	2,414	768.3	6.2
September	1,677	429.1	4.7	50.9	889	414.3	12.5	49.1	2,566	843.4	6.8
1905.											
October	1,567	564.7	6.2	69.1	803	374.2	11.3	39.9	2,370	938.9	7.6
November	1,678	759.8	8.4	71.4	652	303.8	9.2	28.6	2,330	1,063.6	8.6
December	1,894	877.5	9.7	76.6	574	267.5	8.1	23.4	2,468	1,145.0	9.2
			100.				100.				100.
Totals	21,612	9,079.8	.....	....	7,107	3,311.9	.....	....	28,719	12,391.7	.....
Percentage of total collection	75.2	73.3	.....	....	24.8	26.7	.....	....	.....	.....	....
Quan'ty per 1,000 inhabitants per day	2.77	1.164	.....	....	0.91	0.425	.....	....	3.68	1.589	.....

Remarks—1 ton = 2,000 lbs. Daily collection of refuse, except Sundays. Average weights per cubic yard: Ashes and Rubbish, 0.42 tons; Garbage, .466 tons.

TABLE NO. II.—PERCENTAGE COMPOSITION OF HOUSEHOLD REFUSE BY WEIGHT.

Month.	From Table I. Ashes and rubbish.	From Table I. Garbage.	From mechanical analysis. Fine Ash.	Clinker.	Glass, metal, etc.	Coal and cinders.	Garbage. Vegetable.	Garbage. Animal.	Garbage. Free water.	Garbage. Rubbish.
1906.										
January	83.5	16.5	40.5	1.4	3.1	34.7	14.3	0.6	0.7	4.7
February	87.6	12.4	40.3	1.3	3.4	38.3	10.9	0.4	0.3	5.1
March	86.0	14.0	42.6	1.2	3.1	35.5	12.2	0.5	0.6	4.3
April	79.3	20.7	40.8	1.0	3.2	31.5	17.9	0.8	0.8	4.0
May	78.7	21.3	37.7	0.6	5.7	31.8	18.7	0.7	0.7	4.1
June	71.9	28.1	30.7	11.1	8.4	16.2	24.4	1.0	1.4	6.8
July	58.3	41.7	23.8	0.8	9.0	12.6	36.3	1.6	1.7	14.2
August	54.3	45.7	20.0	0.5	10.9	9.0	39.7	1.7	2.0	16.2
September	50.5	49.1	21.7	0.6	8.5	7.7	42.5	1.9	2.2	14.9
1905.										
October	60.1	39.9	20.0	3.5	6.6	15.2	30.9	3.1	1.5	10.2
November	71.4	28.6	31.8	0.7	5.2	30.8	22.6	1.8	1.0	6.1
December	76.6	23.4	34.4	0.9	3.1	34.6	19.6	1.1	0.8	5.5
Averages	73.3	26.7	34.7	1.8	4.8	26.7	22.6	1.2	1.1	7.1

REMARKS.—The "fine ash" noted in Table II. consisted of materials from the "Ashes and Rubbish" collections which passed through a ¾-in. mesh screen. "Coal and Cinders" compose materials rejected by the screen and not otherwise classified. "Clinker" consisted of large lumps which could be picked out of the "Ashes and Rubbish" by hand. "Free Water" in garbage consisted of the water lost in handling the material. The other constituents are self-explanatory.

23. BOILER.—As no decision has yet been made with regard to the utilization of steam power produced from the refuse, the Contractor shall arrange a suitable blow-off for escaping steam. The boiler to be installed should be of ample capacity to utilize all heat generated.

24. CHIMNEY.—The chimney will be of reinforced concrete, not less than 125 ft. in height, of sufficient capacity for a plant burning 120 tons of refuse per 24 hours.

25. COMPOSITION OF REFUSE.—The refuse to be burned in the destructor consists of ashes, garbage and rubbish.

Ashes may be defined as the residue from fires in houses, schools, churches, stores, etc., and includes other inorganic materials such as glass, crockery, metallic substances, dirt, dust, earthenware, bricks, stones, etc. Anthracite coal is generally used in the West New Brighton district.

Garbage consists of organic wastes such as vegetable matter and animal matter with grease, water and slop.

Rubbish consists of wood, paper, rags, excelsior, straw, leather, rubber, etc.

Table No. I. shows the quantity and seasonal variations of the different classes of materials as collected in the West New Brighton district.

As the materials noted in Table I. contained admixtures of various kinds of refuse, a mechanical anaylsis or separation into different classes was carried out in order to determine the combustible and incombustible constituents, the results of which are summarized in Table II.

Samples of the different classes of materials mechanically separated as shown in Table No. II. were tested in a calorimeter with the results shown in Table No. III.

TABLE NO. III.—CALORIMETER TESTS. (LEDERLE LABORATORIES.)

Lab. No.	Collections in '05.	Test Results. Calorific power in B. T. U.	Test Results. Per cent. Water.	Test Results. Per cent. Ash.	Com-busti-ble.	Cal. power combust. in B.T.U., computed.
		Coal and cinders.				
4638 A	Feb.	4,230	1.02	61.17	37.81	11,187
4663	Feb.	3,280	1.63	52.14	46.23	7,095
5074 A	Mar.	4,590	1.55	59.11	39.34	11,068
5425 B	Apr.	4,837	1.54	55.54	42.92	11,269
6282	May	2,108	2.74	68.69	28.57	7,378
7359	July	7,710	0.99	39.38	59.63	12,930
7441	Aug.	7,554	2.01	42.42	55.57	13,594
Average		4,901	1.64	64.06	44.29	11,066

Original bulk sample reduced by quartering, pulverized and again quartered down to test sample.

		Garbage.				
4369 A	Feb.	5,320	4.47	32.44	63.09	8,432
4644	Feb.	9,447	2.68	11.92	85.40	11,062
5074 B	Mar.	7,874	0.00	12.19	87.81	8,967
5425 A	Apr.	8,965	0.60	22.48	77.52	11,565
6281	May	8,186	1.63	18.26	80.11	10,218
7356	July	8,878	0.00	13.04	86.96	10,209
7439	Aug.	9,034	1.84	15.16	83.00	10,884
Average		8,243	1.52	17.93	80.55	10,233

Original bulk sample reduced by quartering, moisture evaporated, pulverized and again quartered down to test sample.

		Rubbish.				
4368 D	Feb.	6,940	0.75	17.03	82.22	8,441
4369 B	Feb.	12,634	0.00	5.66	94.34	13,392
4665	Mar.	7,251	2.78	12.58	84.64	8,567
6280	May	7,943	3.70	13.21	83.09	9,560
7357	July	7,781	1.03	21.39	77.58	10,029
7358	July	8,404	0.80	11.93	87.27	9,630
7440	Aug.	8,107	3.77	8.15	88.08	9,204
Average		8,437	1.83	12.85	85.32	9,889

Original bulk sample reduced by quartering, paper portion pulped, coarsely ground with other rubbish, quartered, dried, pulverized and again quartered down to test sample.

		Fine Ash.				
4368 A	Feb.	0,000	3.03	80.45	16.52	.....
4667	Feb.	0,000	0.56	83.67	15.77	.....
Average		.....	1.79	82.06	16.14	.....

Same procedure as in "Coal and cinders."

		Clinker.				
4368 C	Feb.	0,000	1.14	89.25	9.61	.....
4666	Feb.	0,000	0.61	90.34	9.05	.....
Average		.....	0.87	89.80	9.33	.....

Same procedure as in "Coal and cinders."

Average calorific values were recommended by the chemists for computing the probable heating power of the refuse. As the calorific tests were made on materials containing very little moisture, and as garbage consists mainly of water, a series of evaporative tests were carried out to determine the amount of water per pound of garbage (Table IV.).

It should be noted that the calorific tests of garbage in Table III. are exclusive of "Free Water," noted in Table II., and of the water contained in the garbage as shown by Table IV.

By means of the data here presented concerning the proportions and calorific values of the different classes or components of refuse, the contractor may compute a heat balance by which the evaporative power of the refuse can be determined approximately.

Should the contractor prefer in sub-head "f" of paragraph 20 to guarantee a percentage of efficiency of boiler and grate based upon dry refuse, this may be done, and

TABLE NO. IV.—MOISTURE IN GARBAGE: EVAPORATIVE TESTS.

Date.	Weight of samples, lbs. Original.	Dried.	Water. Evaporated, lbs.	In original, %	Hrs. dry-ing.	Av. water by mos., %
Jan. 4, 1906....	46	10.09	35.91	78.2	88	...
Jan. 17, 1906...	50	13	37	74.0	104	75.9
Feb. 8, 1906....	50	13.65	36.35	72.7	136	...
Feb. 26, 1906...	47	13.31	33.69	71.7	144	72.2
Mar. 23, 1905...	50	16	34	68.0	70	...
Mar. 19, 1906...	49	15.09	33.91	69.2	96	68.6
Apr. 1, 1905....	40	12.5	27.5	68.7	70	...
Apr. 7, 1905....	40	11	29	72.5	80	...
Apr. 2, 1906....	42	13.31	28.69	68.3	128	...
Apr. 20, 1906...	50	15.5	34.50	69.0	128	69.6
May 17, 1905...	40	12	28	70.0	70	...
May 25, 1905...	39	12	27	69.2	60	...
May 9, 1906....	47	13.5	33.5	71.3	104	...
May 24, 1906...	50	14.0	36.0	72.0	130	70.7
June 19, 1905...	39	8	31	79.4	60	...
June 9, 1906....	35	13.5	21.5	61.4	88	...
June 25, 1906...	35	10.5	24.5	70.0	112	70.6
July 2, 1905....	30	9.0	21	70.0	60	...
July 22, 1905...	39	11	28	71.8	70	...
July 31, 1905...	39	9	30	76.9	60	...
July 13, 1906...	46	13.5	32.5	70.6	104	...
July 31, 1906...	36	12.5	23.5	65.3	80	71.0
Aug. 6, 1905....	39	9	30	76.9	60	...
Aug. 11, 1905...	38	11	27	71.0	60	...
Aug. 27, 1906...	44	11	33	75.0	60	...
Aug. 14, 1906...	45	11	34	75.5	112	74.7
Sept. 4, 1905...	38	10	28	73.6	70	...
Sept. 18, 1905..	45	13	32	71.1	50	...
Sept. 20, 1904..	38	9.5	28.5	75.0	90	...
Sept. 8, 1906...	45	11.5	33.5	74.4	60	...
Sept. 17, 1906..	44	12.5	31.5	71.6	100	73.1
Oct. 3, 1905....	26	8	18	69.2	50	...
Oct. 17, 1905...	33	12	21	63.6	50	...
Oct. 26, 1905...	29	9	20	69.0	50	...
Oct. 20, 1904..	47	15	32	68.1	100	67.4
Nov. 6, 1905....	44	13	31	70.5	88	...
Nov. 16, 1905...	37	10.92	26.08	70.5	64	...
Nov. 25, 1905...	36.5	12.31	24.19	66.3	104	69.2
Dec. 11, 1905...	45	9.84	35.16	78.1	160	...

Average percentage of water.....71.4.

will be preferred in place of guaranteeing a flat rate of evaporation and an amount of net useful steam per pound of refuse burned.

The foregoing information concerning the composition of refuse from the West New Brighton District is the best available, and while it is probable that the conditions in different years and different seasons of the year may vary, yet the contractor should base his guarantees upon the data contained in Tables I. to IV. When the acceptance test of the destructor is made the refuse to be burned will be analyzed and its water content and calorific value ascertained, so that an efficiency of boiler and grate, based upon dry refuse, may be computed. In this way any variations in composition of the refuse burned during the acceptance test as compared with the data given may be reconciled and the adequacy of the guarantees in subhead "f" of paragraph 20 determined.

COPPER PRODUCTION IN 1905.

In view of the present high prices of copper, unusual interest is attached to a pamphlet just published, entitled "The Production of Copper in 1905," by Mr. Charles Kirchhoff, being an extract from "Mineral Resources of the United States." During the latter part of the period covered by the report, the price of copper rose materially, but it had not attained present prices, the maximum for Lake copper having been 19 cts. per lb. in the early part of December.

The production of copper in the United States during 1905 reached the enormous figure of 901,000,000 lbs., or 402,637 long tons. The Division of Mining and Mineral Resources of the U. S. Geological Survey has collected copper statistics year by year since 1883. A summary of these is given in the accompanying table. The production increased continuously, year by year, during the whole period with the exception of 1886, 1893 and 1901, the decline in the last-named year being very small. From such earlier figures as are available, it appears that the total production of copper in the United States in 1845 was only 100 tons, of which 12 was from the Lake Superior region. The increase by years was almost constant up to and including 1882, but in the last-named year the total production was only 40,467 long tons.

Taking home production, imports and exports into account, the available supply of copper in the United States in millions of pounds was 518 in 1901, 425 in 1902, 546 in 1903, 426 in 1904, and 560 in 1905. The domestic production in 1905 was 901,907,843 lbs., besides which there was imported, in the form of fine copper in ore and matte, 50,105,300 lbs., and in the form of bars, ingots and old copper, 160,619,385 lbs.; making a total of 1,112,632,528 lbs. The exports were as follows: Ingots and bars, domestic, 534,907,619 lbs.; do., foreign, 1,718,584 lbs.; and fine copper in matte, approximately 16,000,000 lbs.; making the total exports of 552,626,203 lbs.

It is estimated that the average selling prices of Lake Superior copper were 11.86 cts. per lb. in 1902; 13.26 in 1903; 13.21 in 1904; and 15.63 cts in 1905. During the first half of 1905, "the market hovered near the level of 15 cts. per lb. for Lake copper." In August the price rose to 16.5 cts. for spot Lake copper, falling to 16 cts. in September, then rising the latter part of November to 17.5 cts. and rising still further, as already stated, to 19 cts. early in December.

A NEW FLEXIBLE ELASTIC COUPLING.*

In motor cars belt transmission has been found impracticable, and in consequence drives have been sought to relieve the engine and gearing from the shocks produced in traveling over an ordinary road. The drive must not be affected by a moderate want of alinement, and the transmission gear has to accommodate itself to a considerable amount of distortion. Both the cardan shaft and the chain drive answer these two requirements, but neither of them has the elasticity of drive which is so desirable for smooth running.

The flexible elastic coupling shown herewith is intended to be used on motor cars and similar work to obviate the disadvantages previously noted. Fig. 1 shows its construction, with casing removed, when used on a cardan shaft to replace the usual universal coupling.

Its peculiar feature consists in the employment of a rubber disc having holes which receive the driving and driven pins, projecting alternately from the faces of the coupling flanges. The flanges are prevented from longitudinal movement by a ball-and-socket connection. Consequently the shafts are free to adapt themselves to any want of alinement, but the ends cannot separate or close up on account of the ball joint. The power is transmitted from one shaft to the other by means of the rubber disc, which obviously will absorb vibrations or shocks, and relieve the engine and gearing from the consequent strain and injury. A cylindrical casing of metal, fastened by screws to one coupling flange, protects the interior of the coupling from dust; but even were the casing absent the effect of dust could not be anything like so harmful as in the case of the ordinary universal joint.

The stresses in the rubber disc are alternately compressive and tensile between each pin and the next. As rubber in tension fails at about 100 lbs. per sq. in., and can only be used with safety under a stress of about 50 lbs. per sq. in., while its safe compressive stress is at least 200 lbs. per sq. in., it is often advisable to use it in compression only. This may be done in the coupling in question by dividing the disc radially in every tension space, so that no tensile stresses can arise. Of course, in this case, if the driving-shaft is reversed, or the car allowed to overrun the engine, the whole of the power is transmitted by tensile stress in the rubber.

For chain-driving the ball joint is dispensed with, as no flexibility is then required, and the coupling is constructed as in Fig. 2. The following half of the coupling rides easily on the driving-shaft, and carries a sprocket-wheel keyed to the outer end of its boss. The flanges are made of cast steel except for marine work, where bronze is sometimes used. They are machined all over to ensure balance. The couplings are made in all sizes from 1/12-HP. for driving small magneto-ignition machines, up to any desired horse-power. They are quite small for the power transmitted; a coupling to transmit 12 HP. at 500 r. p. m. is only 6 ins. in diameter, and weighs 14 lbs. In motor cars where gear-wheel transmission is used, one of these couplings fitted to each end of the cardan shaft provides both a flexible and a spring drive, and acts as a universal joint at the same time.

This flexible elastic coupling is made by Messrs. Rankin, Kennedy & Sons, of Scotstown, Glasgow, Scotland.

*Abstract from an article in "Engineering," of London.

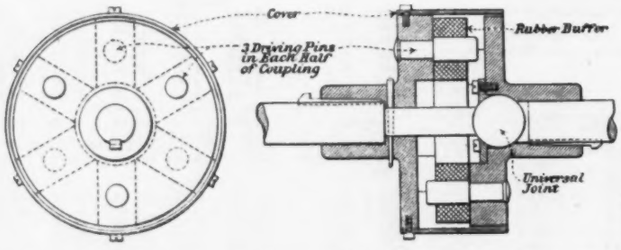


FIG. 1. A NEW FLEXIBLE ELASTIC COUPLING AND ITS APPLICATION TO A CARDAN SHAFT TO REPLACE THE USUAL UNIVERSAL COUPLING.

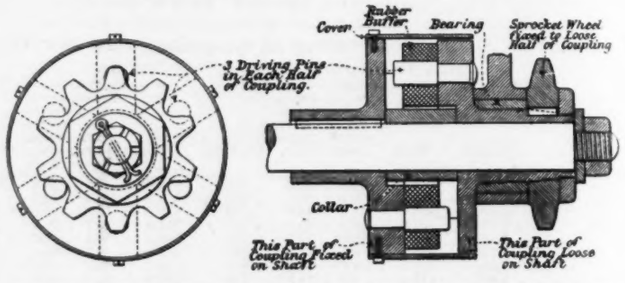

Cover
Rubber Buffer
Bearing
Sprocket Wheel Keyed to Loose Half of Coupling
3 Driving Pins in Each Half of Coupling.
Collar
This Part of Coupling Fixed on Shaft
This Part of Coupling Loose on Shaft

FIG. 2. THE FLEXIBLE ELASTIC COUPLING AS CONSTRUCTED FOR CHAIN DRIVING.

THE WATER SUPPLY AND FIRE PROTECTION OF Milwaukee, Wis., and Cambridge, Mass., have been reported on by the Committee on Fire Prevention of the National Board of Fire Underwriters (135 William St., New York). The Milwaukee water-works, the committee states, are efficiently managed and generally satisfactory, but the main arteries of the distribution system are inadequate, many of the distributing mains are too small, and the gridironing poor, due to lack of connections. The valves are much too far apart, and hydrants are "somewhat widely spaced," besides which many are of an unsatisfactory type. The separate fire main system for a portion of the city is highly praised. The fire department system and fire alarm system are both recommended. The building laws, while containing some good fire protection provisions, "omit many salient features and fail to provide properly for modern types of construction." The ordinances governing explosives and inflammables are meager, and some of their provisions are altogether too stringent for enforcement, and little attention seems to be paid to them by the authorities. The municipality exercises practically no control of electric wiring. The conflagration hazard is severe in the western part of the congested value district, but the good fire-fighting facilities, including fire-boats and special fire mains, put the fire department in a position to confine any fire in this district to a small area. At Cambridge the water-works are considered as satisfactory, on the whole, but a considerable proportion of the distributing mains are too small and the hydrants need more frequent inspection. The fire department is undermanned and the engines are inefficiently handled, and altogether this department is characterized as "inefficient, and not capable of handling serious fires." This deficiency is all the worse because the "fire alarm system [is] unreliable, apparatus at headquarters [being] 'fit only to be thrown away' and improperly housed." The conflagration hazard is "severe locally, owing to the structural defects in several blocks containing large area buildings, lumber yards and a large per cent. of frame construction, which, in connection with the lack of individual building protection, poor street paving, and inefficient fire department and fire alarm systems, give a high probability hazard." To offset these defects there are the good water supply, outside aid quickly attainable, and sprinkler protection for a number of the largest risks.

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Philadelphia is now adding to the evidence already contributed (Eng. News Nov. 8 and 29) by Washington and Baltimore to the effect that other causes than water are responsible for much of the typhoid fever prevalent in some of our American cities. By a coincidence similar to that already recorded in the case of Washington, the extension of the filtered water service to additional districts of West Philadelphia in April and early in November of this year has been followed by increases in the number of cases of typhoid fever reported in that section of Philadelphia. According to a statement by Major Cassius E. Gillette, Chief of the Philadelphia Bureau of Filtration, filtered water was first supplied to a small portion of West Philadelphia on June 3, 1904. In February, 1906, an additional section was supplied, and since Nov. 4, 1906, all of West Philadelphia has received filtered water. In the district first supplied with filtered water 43 cases of typhoid fever were reported up to Nov. 3, 1906, as compared with 15 for the same period in 1905. Comparative figures for the additional district supplied in February, 1906, are not available; Major Gillette states, but we understand that there has been an increase there also. In this district and in all the rest of West Philadelphia outside the district supplied with filtered water in June, 1904, there were 643 cases between Jan. 1 and Nov. 23, 1906, as compared with 512 cases for the same period in 1905. For the week ending on or about Nov. 30, there were reported 1 case in the old district, 2 in the extension (making only 3 cases for a population of 83,000) and 11 cases in the remainder of West Philadelphia. This remaining portion, it should be understood, has not had filtered water long enough to show any effect therefrom. It should be remembered that by far the larger part of Philadelphia is still using a badly polluted unfiltered water supply, so that many of the people in any of the filtered water districts are liable to infection from water drunk in other sections of the city and by various other channels that always exist in a typhoid-ridden community. At another time the increase in typhoid at Philadelphia would attract no attention there and would not call for comment in these columns, but being coincident with extensions of the supply of filtered water the increase in the prevalence of the disease has given rise, as was the case at Washington, to questions regarding the efficiency of the filters. Major Gillette is authority for the statement that the filters have been giving very good bacterial results, so that altogether they seem to be in no way to blame for the recent increase in typhoid in West Philadelphia.

The Philadelphia newspaper editors, with the Washington studies fresh in their minds, are pointing out that the water supply must not be blamed for the incident. A few more notable cases of this kind may do much towards putting health authorities at work to guard every avenue of typhoid infection, instead of relying so much as heretofore upon agitation for improved water supplies. Good as the latter sort of agitation is, it is not sufficient, as events are showing.

The municipal authorities of the Borough of Richmond, New York City, have had the courage to draw specifications and call for bids for a refuse destructor essentially on the lines of recent British practice, not omitting provision for heat utilization. The most significant portions of the specifications are printed elsewhere in this issue. They require bidders to submit general plans for the destructor buildings and accessories and complete plans for the destructor, and to submit a lump bid for the sale of all the plans to the borough and for erecting and equipping the proposed destructor. The specifications exclude bids from any one who cannot furnish a certificate from the engineer in charge of a destructor similar to the one proposed, showing, among other things, that the destructor has been supplying heat that has been utilized for municipal purposes.

A notable feature of the specifications is their inclusion of detailed monthly records of the amount and composition of the refuse to be dealt with, and also the results of a series of calorimeter tests of the various components of the mixed refuse and evaporative tests of the moisture in the garbage. This tabular data is the most extensive and complete that has ever come to our attention. Although a water tube boiler for the utilization of the destructor heat is to be provided it has not yet been decided how the steam raised by the boiler will be utilized. That decision is wisely reserved until after operative tests have determined how much heat will be available. The initial plant will have a capacity of 30 tons a day, six days in the week, and will serve a population of about 26,000.

The date set (Dec. 27) for opening bids for the destructor will be awaited with great interest by many, for the number and names of prospective bidders, as well as the terms offered, may throw some light upon probable future developments in the disposal of municipal refuse. The Staten Island proposition must be considered as to some extent experimental, since so little has been done in the way of high temperature destruction of mixed refuse in the United States. On the face of the data in the specifications, it will be feasible to produce heat in utilizable quantities. The questions are: How much will such heat cost, capital and labor charges included, and what can the Borough of Richmond do with it? As the borough is a part of the great city of New York, the refuse disposal problem of which is by no means settled, the proposed experiment is well worth trying.

A peculiar state of affairs must exist at Lebanon, Pa., or that city of some 20,000 inhabitants would not be seriously proposing to farm out to a private company such sanitary work as providing its citizens with sewerage facilities. Even the most ardent opponents of municipal ownership have always taken it for granted that sewerage systems should be publicly owned and controlled. It is true, however, though few people know it, that there are in the United States a score or so of cities and towns that are served by private sewerage companies, operating under municipal franchises and collecting annual charges from owners or occupiers of buildings connected with the sewers. It is conceivable that such an arrangement may be justified in some unprogressive or debt-ridden municipality, but rarely on any other ground than that a municipally-owned sewerage system is impossible. At Lebanon, "limited borrowing capacity" and the impossibility of providing funds for other improvements if the credit of the city be used to raise money for sewerage, and the necessity of a considerable expenditure for disposal works are the reasons advanced for granting a sewerage franchise. We do not pretend to a knowledge of local conditions at Lebanon, but it does seem strange that a city of its size should be unable to finance a sewerage system without unduly postponing other public improvements. It is hardly necessary to say that the chief objection to a sewerage company is that it must charge rentals for the use of its sewers and that this discourages sewer connections. As a rule, the use of municipally-owned sewers is free; that is, there is no annual charge, although there is generally an entering charge, and frequently an assessment-for-benefit, as well, the latter being levied against all property on the lines of the sewers, whether connected or not. Every sewerage engineer or superintendent knows full well, and health department officials know even better, that it is difficult enough to induce or compel property-owners to connect with sewers, even when there is no annual rental to be paid. How this difficulty will be increased, in both degree and complexity, when the annual rental must be paid to a private company will be appreciated by everyone familiar with the present attitude of the public mind towards corporations in general and public-service corporations in particular. Where it is considered necessary to grant a sewerage franchise, provision should be made for municipal purchase at any time, so the city can assume full control of the sewers as soon as it is able to do so. In the proposed Lebanon franchise the purchase clause does not become operative until 30 years after the franchise is granted. This would compel the citizens of Lebanon to pay sewer rentals for 30 years, regardless of any changes in local conditions that might make city ownership at an earlier date entirely feasible. Finally, the proposed Lebanon franchise is altogether too indefinite in its provisions regarding the character of sewage treatment works, this important subject being covered in a blanket clause of about a hundred words. The necessity for sewage treatment, whether at Lebanon or elsewhere, makes municipal ownership all the more desirable.

We risk little in saying that the most remarkable presidential address ever delivered before an American engineering society is that presented this week by President Fred W. Taylor before the American Society of Mechanical Engineers, on "The Art of Cutting Metals." As many of our readers know, President Taylor and his associates have been engaged for over twenty years in work looking to the improvement of machine-shop practice. One of the results of their labors has been the development of high-speed tool steel, which has practically revolutionized machine-shop work all over the world. Instead of adopting the common course of presenting an address dealing largely with platitudes, at the close of his presidential year, President Taylor has taken the remarkable step of spreading before the engineering profession the information gathered in the course of over two decades of investigation, which information has been hitherto kept private as a commercial asset in connection with professional work in the improvement of shop practice. The address as presented in the Society's Proceedings consists of two parts: The first, a general summary of the investigations referred to and of their general effect on shop practice; this part we reprint in full on another page of this issue. The second part really deserves the name of a treatise, occupying between two and three hundred pages of the Society Proceedings, and presenting by far the fullest statement of developments in the art of cutting metals that has ever been anywhere published. In a following issue we shall attempt some abstract of this second portion of the address, but any complete publication is, of course, beyond the possibilities within our limits of space.

We trust President Taylor's example may be imitated by other presidents of national

engineering societies. When a man reaches a stage of professional advancement that justifies his elevation to the highest office within the gift of his professional brethren, it seems fitting that he should in return make the most valuable contribution to professional literature of which he is able. Instead of attempting a general survey of the whole engineering field, as has very commonly been done in presidential addresses, it seems particularly appropriate, where a specialist is elevated to the presidency, that professional literature should be enriched by the most complete statement regarding his work in that specialty that can be presented.

The contract for construction of the Panama Canal, on which bids are to be received on Dec. 12, has been undergoing careful study by contractors in all parts of the country during the past few weeks, and many queries have been raised as to where the contract originated. We are able to state that the original draft of this contract, or rather a general plan embodying all the essential features of the contract as finally adopted, was prepared by Mr. John F. Stevens, Chief Engineer of the Panama Canal Commission.

Few members of the engineering profession have had a broader experience in dealing with contract work on large enterprises than Mr. Stevens. He has been the engineering head in the construction of many hundreds of miles of railways in the West and has also been an engineer for contracting firms and has done contract work on his own account. He went on record at an early stage of his connection with the Panama work in favor of the general plan of letting the work to contract instead of doing it by day's work; but of course nothing could be actually decided or done with reference to letting contracts until Congress fixed the type of canal. The law fixing the lock type for the canal was passed in June last, and within a month after that time, a plan of contract embodying all the essential features of that now offered to bidders was submitted by Mr. Stevens to the Chairman of the Commission. Most careful study has been given to this plan by the members of the commission and their General Counsel, Mr. Rogers, and by Secretary Taft himself, and it has been critically discussed by prominent engineers and contractors. The verdict appears to be that under the peculiar conditions governing the work at Panama, nothing could be devised which would better insure to the Government the rapid and economical construction of the canal, while involving the contractor in a risk very small in comparison with the magnitude of the work, and promising him sufficiently large profits to induce his best efforts.

The Pan-American R. R. referred to in the newspaper quotation which we published last week in connection with our remarks on the Hartley advertisement, is a railway with about 160 miles in operation, according to its time table as published in the "Official Railway Guide," while the "Pocket List of Railway Officials" also states that "200 miles are under construction." Mr. J. M. Neeland, of Los Angeles, is Vice-President and General Manager; and Mr. S. C. Miller, of Tonala, Mexico, is Chief Engineer. This road connects with the railway system of Mexico at San Geronimo, and is understood to be building an extension to connect with a Guatemala railway. We are not informed as to whether Hartley traded on the reputation of this company by claiming to be its authorized representative, or whether he invented a Pan-American Co. of his own.

FRANCHISES FOR RAILWAY TRACK construction, will not be granted by the Rapid Transit Board of New York without making yearly rentals obligatory and providing that the terms with the city be readjusted every 25 yrs. This statement was made Nov. 23 by Alexander E. Orr, President of the Board, in considering the connections desired by the Long Island R. R. Co. in Long Island City, which was up before the Committee on Plans and Contracts. Permission was asked to make these connections without paying the city a fixed amount annually, and a franchise in perpetuity was also demanded.

WHAT CAN BE DONE TO REDUCE THE NUMBER OF RAILWAY ACCIDENTS?

Two weeks ago, with all the harrowing circumstances of the recent railway horrors at Atlantic City and Woodville, Ind., fresh in mind, we urged that a system for the thorough investigation of railway accidents by Government experts should be established in this country. Such a system of accident investigation has been in operation in Great Britain for over thirty years. We printed one of these expert reports on an English trolley accident in our issue of Nov. 22, and in this issue we print the report upon the disastrous derailment at Salisbury, England, last summer, in which a number of well-known Americans were killed.

Two causes impel us to return to the subject again. One is the receipt of a letter printed below, from the President of one of the largest American railway systems. The second cause is the shocking death of President Samuel Spencer, of the Southern R. R., in a rear collision which occurred on that railway on the morning of Thanksgiving Day.

The letter referred to reads as follows:

Sir: I have read your recent comments on the subject of a department of the Government to investigate railway accidents.

It does not seem to me that Engineering News is taking the view which a technical paper might properly be expected to take. You have jumped at the conclusion that railroads do not thoroughly investigate accidents; I think this is a very unwarranted conclusion, and seems to be based wholly on the fact that railways do not publish the results of their investigations. My own observation leads me to think that every important railway company and every good railway management makes a most thorough investigation of any serious accident, and that these accidents are discussed between the officers of various railways, with the view of trying to determine what the proper remedy is.

The recent serious accident on the Atlantic City line of the Pennsylvania, and on the B. & O. line in Indiana, near Chicago, have been common subjects for discussion by railway officials. What right has Engineering News to say that they have not been thoroughly investigated?

Then again, Engineering News suggests that the proper remedies are not applied. In many cases the most effective and complete remedy involves a very large expenditure; for example, extensive double tracking, automatic block signaling, and other devices. Can railway officials get these improvements by simply wishing for them? With freight rates stationary or going down, with passenger rates being reduced by state legislation, with the price of materials and the wages of employes going up, many railways of the country are unable to secure the added capital which they very much desire for many improvements.

I notice you refer to the precautions taken to protect the cotton manufacturing interests of the country from fire. Mr. Edward Atkinson, to whom you refer, I knew very well. He was employed by prominent cotton manufacturers who allied themselves in an association for mutual protection. This is as if the railways should get together and select a man to investigate accidents and devise a remedy, which is a very different thing from having the Government take it up.

Yours truly, F. A. D.

Western Union Bldg., Chicago, Nov. 26, 1906.

Our correspondent says that "every important railway company and every good railway management makes a most thorough investigation of any serious accident." Does he not really mean as thorough an investigation as the operating officers can make in such time as they have to spare? We are well aware that it is the practice to have trainmasters and division superintendents investigate accidents far enough to place responsibility on particular employees at fault and to exercise discipline. In such investigations at times, the signal engineer—if the road has one—the Superintendent of Motive Power, the Chief Engineer or other officials may take part.

But when all is said and done, how do these secret, railway company investigations compare with such a thorough-going piece of work as Major Pringle's investigation of the Salisbury disaster in England? It is well enough for your trainmasters and division superintendents to find what engine-runner or conductor or flagman was at fault for a collision, or even what appliance was effective in causing or preventing a wreck; but what railway company [illegible] beyond this? Can our correspondent recall one such investigation in which it was found and reported—that the fault at bottom was [illegible] defective method of operation or defective appliance, whose continued use may have been due to ignorance or prejudice or worse, of a General Manager or a President, or perhaps of men even higher up who run railways from the financial side and not from the operating side? We have no desire to indict railway management, but surely any one can see that the present system of railway company investigations of accidents is pretty nearly equivalent to setting a man to investigate his own acts—or the acts of his superiors.

In the second place, our correspondent admits that railway companies keep secret the results of their investigation, and by this admission he really proves that the present plan of letting the railway companies investigate the accidents themselves is a failure. What is the object of investigating these railway accidents? Surely the one great object ought to be to diminish the liability of their recurrence. To investigate to see wherein a brakeman or conductor or engineer blundered and to punish those at fault by suspension or discharge may be well enough, so far as it goes; but cannot our correspondent see that it does not go far enough?

We want investigations that will lay bare the whole matter in relation to every serious railway accident; that will make clear the lessons which ought to be learned from it; and—most important of all—that will bring home these lessons to the whole body of railway officials and employes.

The railway companies may make their investigations ever so thorough; but so long as they adhere to the secretive policy and confine the knowledge of the circumstances of an accident to a chosen few of their own officials, so long will accidents from the same old causes occur again and again with such monotonous regularity that the railway officials and even the public become hardened to them, and—we regret to say it—oblivious to the lessons they ought to teach.

Our correspondent has referred to the Atlantic City disaster. It illustrates well the point we wish to make. The West Jersey & Seashore R. R. officials doubtless made their own secret investigation, as our correspondent says. Its results are known—confidentially—to a number of the higher officials of the Pennsylvania Railroad System. Possibly a few officers of other roads may casually learn in time of the actual results of that inquiry. But for every railway official who receives this information, a dozen or a hundred will read in the daily newspaper that the cause was an impenetrable mystery, that the bridge and signaling appliances were as perfect as they could possibly be made—witness the sworn testimony of the engineering head of a great bridge company.

And with such knowledge of the actual circumstances as this, our correspondent says—no doubt truly—that this accident was common subject for discussion among railway officials! What does discussion amount to in the absence of knowledge of the actual circumstances? Is not such discussion as this among railway officials, with that little knowledge of facts which is proverbially dangerous, responsible for many of the crude ideas and prejudices which are so widespread?

Let us make the case still more definite: The lessons of the Atlantic City disaster, written so large that anyone could read, were: (1) put inside guard rails on your bridges, (2) make your drawbridge interlocking systems complete. Those lessons ought to be brought home with force and conviction to every responsible railway officer in the country; but how many such officers does our correspondent think will ever hear of them from the railway company's own investigation? Instead there went out to the newspapers of the country the testimony of an official that inside guard rails were dangerous!

Let us turn now to the fatal disaster on the Southern Ry. in which one of the greatest of

American engineers, Samuel Spencer, lost his life. The prominence of Mr. Spencer and of the friends who died with him rivets public attention upon this accident. The general circumstances have already become known to most of our readers, doubtless, through the daily press; but we may briefly state here from the information at present available that the collision appears to have been primarily due to an error of a block signal operator. The collision occurred after the two trains (No. 33 and No. 37 following) passed the signal tower at Rangoon and before they reached the tower at Lawyers, four miles farther south. The following relating to the accident is taken from the New York "Tribune" of Dec. 1:

An examination by an Associated Press representative of the telegraph sheets kept at the Rangoon and Lawyers block offices shows that Mattoax, the operator at Rangoon, allowed train No. 33, the Jacksonville Express, upon the block, the train passing his station and getting a clear track from him at 6.06 o'clock.

The operator at Lawyers, the next station ahead, claimed that Mattoax did not ask him for a "clear track" for No. 33, and he therefore did not know this train had passed Rangoon.

The block sheet at Lawyers bears out this claim. The sheets at both offices show that the operator at Rangoon asked Lawyers for a clear track for No. 37, the Washington and Southwestern vestibuled limited, and the Lawyers operator, not knowing No. 33 was in the block, gave No. 37 the right of way at 6.14 o'clock, and No. 37 passed Rangoon at that time. If Mattoax had reported train No. 33 on the block to Lawyers there would have been no accident, because the operator at Lawyers would have held the Southwestern Limited at Rangoon until the Jacksonville train had cleared the block at Lawyers.

It is well enough to inquire into the failure of the signal operator to do his duty, but it is of far more importance, for the prevention of similar accidents, to ask what additional safeguards of system and of appliances can be put in force to prevent such fatal lapses of memory on the part of signalmen.

Apparently the block system as operated on the Southern Ry. main line is the very simplest form of telegraphic block. There seems to have been no mechanical check to prevent the operator giving a train a clear signal without permission from the operator in the block tower ahead. If there had been, Rangoon would have been compelled to report to Lawyers the passage of No. 33. Or if there had been a track circuit system, in use, Rangoon could not have cleared his signal for the next train till No. 33 had passed out of the block. The failure of the time-honored (or time-condemned) plan of relying on the rear flagman is shown by the fact that although the flagman did go back, and was seen by the engineer of the following train, who applied his emergency brakes at once, the train could not be stopped soon enough to avoid striking and telescoping the private car on the rear of the standing train.

So far as at present appears, therefore, the lesson of this latest disastrous wreck is that while any form of blocking is better than nothing, it is worth while to surround even a simple telegraphic block with such mechanical appliances as will aid to prevent fatal errors on the part of the towermen. This lesson ought to come home with the more force to railway officers because of the prominence of the principal victim.

But it may be asked what could a Government investigator do in relation to this particular accident? He could make known to the railway officers and employees the country over, all the facts relating to the occurrence. It has been widely advertised that this was a collision under the block system. In the interests of sound railway practice, it ought to be made public just how much—and how little—of a block system it was. In the interests of sound discipline, block signal operators, the country over, should have placed before them the particular error of which one operator was guilty and its disastrous results.

We may go one step farther and set down what is, we believe, pretty well known to railway men. The main line of the Southern Railway, on which this collision occurred, has had a bad reputation for at least five years, and we do not know how much longer, for its great number of train wrecks. The traffic carried long ago outgrew the facilities for moving it and the system for protecting the trains on the road. Had these accidents been investigated by competent Government experts, instead of—according to our correspondent—by the railway company itself, we cannot help believing that long ago something would have had to be done for the betterment of operating methods. It might well be that such improvement would have averted the collision that cost President Spencer's life.

By a curious coincidence, on the same day with the reports of the Southern wreck there appeared in the daily papers interviews with one of the principal officers of the Great Western Ry. of England, who is spending some time in the United States. Asked for his opinions of American railway practice he expressed great admiration for American methods of moving great volumes of freight at low cost, but frankly revealed the fact that American practice in signaling and the protection of trains made him stand aghast.

And now finally, a word in answer to our correspondent's plea of poverty near the close of his letter. Whatever the circumstances of individual roads may be, the fact is, as shown by the figures published in this column last week, that the railways of the country were never more prosperous than they are to-day. Taken as a whole the railways of the country can well afford the appliances and methods necessary for safe operation. Wherever they cannot, they should reduce train speeds to such a point that safety *will* be secured.

The plan of letting the railways conduct their own secret investigations of accidents has been long on trial and the slaughter and maiming still goes on. Is it not time the secret policy in railway matters was abolished? Is it not time the public, whose lives and limbs are at risk, should assert its right to some knowledge of the methods which are being used (or are not being used) for its protection? Why not *try* the plan of Government investigation? What have the railways to fear from it? Why should railway officers oppose it when their own lives are oftenest the ones at stake? If the reason is that on many railways the methods in use will not bear a critical examination, then there is all the more reason why such an examination should be made.

Since the preceding was in type we have received the following letter from Hon. Edward A. Moseley, Secretary of the Interstate Commerce Commission:

Sir: I have noted with interest the editorial articles in your issues of Nov. 15 and 22 concerning the Government investigation of railway accidents.

I am exceedingly glad to know the attitude which you have taken on this question. This is a matter that has caused the Commission considerable concern for some time past. In its report to Congress for 1904, a strong recommendation was made for a law authorizing investigation by the National Government of all accidents on railroads engaged in interstate commerce after the same plan as is followed by the Board of Trade in Great Britain. We renewed this recommendation in our report for 1905, and in an appendix to that report gave further reasons why such an investigation should be had, and quoted a memorandum published by the Board of Trade showing the methods of investigation in vogue in Great Britain. The Commission will undoubtedly make further recommendations on this matter in its forth-coming report to Congress.

This is a matter of extreme importance, and such journals as yours can do no greater service to the public than to strongly agitate for the passage of such a measure by Congress. It is impracticable for the States to take the matter up in any way that will secure efficient results. In the first place, the question of the interstate character of the carrier would come up as a bar to the authority of state officials to regulate the matter. Again, the impracticability of any state going to the expense of employing a competent expert to investigate the small number of accidents which would come exclusively under state control negatives the idea of any such treatment. It is a national question and can only be properly treated by national authority.

The terrible accident which has just occurred on the Southern Railway, of which President Spencer was one of the victims, is a case in point. The Government will have to be content with the report of this matter furnished by the railroad company, and this report will undoubtedly place the blame upon some subordinate employe; whereas, if the matter were thoroughly investigated by experts which the Government would employ under proper authority of law, it might possibly be discovered that the method of operating the block system on the Southern Railway is wrong.

I am sending you herewith marked copies of extracts from our 18th and 19th annual reports wherein we have recommended the investigation of accidents by the National Government, and refer you to pages 103-4-5 of our 18th annual report, and 77-8 of our 19th annual report, and also pages 168 et seq. of appendix D of the 19th.

Trusting you will continue agitation along this line until proper results are secured, I am,

Very truly yours,

E. A. Moseley, Secretary.

Washington, D. C., Nov. 30, 1906.

As particularly pertinent in connection with the preceding discussion, we reprint below the extracts from the last two reports of the Commission referred to by Mr. Moseley:

(From the Commission's Report for 1904.)

The great increase in train accidents during the past year has led to widespread discussion, and the causes assigned for various accidents are numerous and conflicting. Among these causes have been mentioned the influence of labor unions, laxity of discipline, long hours of labor, employment of inexperienced men, overtaxing the facilities for handling business, and many others. The fact that there exists so wide a diversity of opinion on this important subject, and a careful examination of the reports sent in by the railroad companies, covering the more serious accidents, suggests that if the public is to be supplied with full and accurate information concerning the causes of such accidents the facts ought to be made the subject of an impartial investigation on behalf of the Government. If, as has been asserted, the block system is no remedy for collisions, because railroad managers are unable or unwilling to enforce proper discipline and prevent men from ignoring rules and disobeying signals, there is certainly great necessity for thorough investigation of railway accidents by Federal authority, so that proper remedies may be decided upon and introduced for the protection of the public.

It is impracticable to formulate a code of questions that will elicit satisfactory answers by letter in cases where the cause of a collision or derailment is complicated or obscure, or the responsibility is chargeable to two or more persons; for cross-examination is often necessary to disclose the true facts. Besides this, railroad officials often seem to think that it is their duty to withhold facts, on account of some real or supposed liability to make disclosures that will impair the railroad's rights or interests in future judicial proceedings. Some companies seem to have adopted a settled policy to give the least possible information, at all times, on any and all subjects.

The object of an investigation would be to give a clear and simple explanation of the facts and circumstances of an accident for the information of the public. The inquiry should be independent of all coroners' investigations, or criminal or civil proceedings in the courts, either State or Federal, though the Federal investigating officer should have the privilege of appearing at inquests and questioning witnesses. For his own investigation he should, of course, be authorized to employ the powers of the Federal courts to compel the attendance of persons and the production of papers, though it is not likely that such powers would often have to be exercised, as all railroad officials may be expected to cooperate willingly in examinations which are conducted on a rational basis, and which aim only at a true explanation of the actual facts and conditions. In a few of the States, railroad accidents are investigated more or less fully under State authority. A Federal inspector would not interfere with one acting for the State, and would usually cooperate with him, so that there would be no serious duplication of effort or of expense.

The need for such investigation is the greater, because the conditions which result in collisions exist all the time. The idea that an unusual volume of traffic, such as that occasioned by a world's fair, is a cause of collisions must not be allowed too much prominence. A sudden or large increase in traffic may sometimes lead to the employment of trainmen who lack proper experience in their duties, and to that extent may be looked upon as the occasion of an enlarged casualty list, but the real difficulty lies deeper than this. The errors committed by these inexperienced men are the same in kind as those committed by the experienced, and committed at times of light traffic as well as heavy. The collisions that cause deaths by the score and arouse the indignation of the whole public are due to causes which figure in the records every month. The question at issue is the abolishment of these causes without regard to whether the

results be the death of a single unknown and obscure brakeman or a great catastrophe killing large numbers of passengers.

(From the Commission's report for 1905.)

The investigation of train accidents is a matter of public interest, for the reason that the causes of such accidents are often complicated or obscure. The responsibility for a collision is frequently chargeable to two or more men connected with the management of a train, or to one or more telegraph operators or signalmen, or to one or more officers, or to all these classes. A cross-examination and sifting of evidence is often necessary to get at the truth. The reports made under the present law are based entirely on the statements of officers of the railroads involved, who, for various reasons, might feel it their duty to conceal the facts, and, with the best of intentions on the part of officers of the railroads, it is difficult, if not impracticable, to formulate a code of questions to be sent by mail which will elicit all the information necessary to clearly explain a collision or derailment. In many cases there are subsidiary questions, such as the causes and effects of fires, which need to be elucidated, although perhaps not strictly to be classed as causes of the accident.

The right of Federal investigation of accidents may be questioned, the contention being that this is a matter which should be dealt with solely by State authority. When it is considered, however, that all railroad companies, with very few exceptions, carry both passengers and property without regard to the citizenship or locality of ownership, and that some State authorities are apparently indifferent to the subject, and that many accidents would be avoided by supervision and a full understanding of existing conditions, it may be that it is the duty of the Federal Government to obtain fuller information and to take such steps as will be conducive to safety, particularly as Congress has exclusive authority over highways while transporting interstate traffic.

LETTERS TO THE EDITOR.

Flies as a Possible Important Factor in the Spread of Typhoid Fever at Washington, D. C.

Sir: In Mr. Horton's article on typhoid fever in Washington, published in Engineering News of Nov. 8, 1906, are two diagrams, one showing the deaths from typhoid fever by months, for twenty-two years, and another showing the relation between such deaths and temperature, humidity and rainfall. In examining the first of these diagrams, I was struck with the coincidence of the annual fever wave and "fly-time," when allowance is made for time of incubation and the long period that frequently elapses before death. The remarkable parallelism of the fever curve with the temperature curve shown in the second diagram is discussed, and I want to call attention to the fact that a resultant of the temperature and humidity curves would closely indicate the intensity of the fly pest for the season. The thousands of privies would supply this material, and the flies furnish the transportation for typhoid infection. This makes the fact that the growth and decrease of typhoid fever coincides so uniformly for so long a period with the coming and going of the flies significant.

I do not wish to confuse co-existence with causation, but as something other than the water supply must be blamed, if credit be given to reliable reports of filtration results, I think the striking coincidence above mentioned should raise the question as to whether flies are not a major rather than a minor factor in this case.

Respectfully,

John B. Harper, M. Am. Soc. C. E.

Black Rock, N. Mex., Nov. 19, 1906.

The Bixby Hotel Failure: Influence of Ground Plan.

Sir: In regard to the collapse of the Bixby Hotel at Long Beach, Cal., on Nov. 9, of which you give an account in your issue of Nov. 29, it is only necessary to consider the H-form of the plan of the structure to realize the danger to which the structure would become subject in the case of an uneven settling of the foundations.

The concrete stair shown in the center will, owing to the nature of the construction, afford an excellent distribution of the loads under the center portion of the building, resulting in less intensity of load on the foundations at this spot than under the wings. It is evident that any settling of the wings will cause the center portion of the foundations to become the fulcrum for the weights of the structure (or at least for a portion thereof), and the tensile stresses this would give rise to in the upper floors would tear these floors and cause them to sink, dragging the columns with them.

The H-form is a most unfortunate choice for a building of any kind not erected on bed-rock.

Yours respectfully,

E. R. T. Berggren.

531 West 151st St., New York, N. Y., Nov. 30, 1906.

The Present State of Reinforced-Concrete Construction.

Sir: Thanks are due you for the fearless arraignment of the "carelessness, incompetence, and unscrupulous skinning" which seems to be fast becoming a characteristic of present-day reinforced-concrete construction. The practice of giving a contract to the parties that can "skin" the material the closest has been carried over into reinforced concrete, where as you say, it is universal. The parties so classed are becoming numerous, since irresponsible and often ignorant ones are going into the building business, lacking the essential qualifications, to the benefit neither of the material men nor the owner nor themselves, as the daily record of liens and judgments attests: Fools rushing in where angels fear to tread.

Yours truly,

A. N. Muller.

287 Fourth Ave., New York, N. Y., Nov. 30, 1906.

The Design of Reinforced Concrete Retaining Walls.

Sir: Kindly permit me space to reply briefly to Mr. E. P. Goodrich in his criticism (Eng. News, Nov. 15) of my article on design of reinforced concrete retaining walls (Eng. News, Oct. 18, 1906).

As to the placing of straight horizontal and vertical rods being simpler than for the inclined rods used by me, my idea would be to have the rods and angles sent cut and punched and threaded to the site. The harp-like arrangement in each rib or counterfort can be set up on the ground and raised to position. A few braces would hold all in place, whereas, with all rods separate, each would have to be held individually, and liability to displacement is multiplied.

The total pressure against the front slab is less than that against the bottom, hence with the same rods, starting normal, there is more than enough strength to take all of the force. The occurrence of rods apparently closer than necessary near the top of front slab will give an extra safeguard against such pressure as that due to freezing of the ground, which would be greatest near the surface. Extraneous load would probably effect a lateral pressure near the surface only.

In the matter of the projection in front of the wall, and of the steps being without reinforcement, it is seen by my sketch that the front projection is only one-third as broad as its height; also the uplift under the steps tapers down to nothing at the foot of the steps. There is strength enough in the concrete to take the resultant tension at a very low value. Spread footings are allowable even in brick or rubble masonry; they ought to be so in monolithic concrete. If there were necessity for a large projection in front of the wall, a modified design would be required. It was my purpose to give a rational analysis of the stresses and rational methods of taking care of them.

Yours very truly,

Edward Godfrey.

Monongahela Bank Bldg., Pittsburg, Pa., Nov. 19, 1906.

Concerning Safe Reinforced-Concrete Construction.

Sir: I see in your issue of November 22 a letter from Mr. James Ritchie concerning competence of engineering design and supervision for reinforced-concrete work. I agree with him that it is a dangerous practice to let the responsibility of designing a reinforced-concrete structure rest upon a contractor's shoulders before having the perfect certainty that this contractor is himself (or employs) a competent specialist.

As to the assertion that contractors very often sacrifice the strength of the building to the increase of their profit, this applies to firms which do not consider their good renown and do not care to be well established and considered.

Unfortunately for the serious contractors who have a record of several years of satisfactory work, the great opportunity brought to light by the recent disastrous fires has given birth to some reinforced-concrete firms conducted by men who were at one time plain concrete or simply masonry contractors and who know nothing about reinforced concrete, except that it is made of steel embedded in concrete. For these contractors there is no difference between the cost of plain and reinforced concrete, and they make up their bids accordingly. The result is that they underbid responsible competitors by sometimes great sums. If they are awarded a contract, it becomes a necessity for them to save money by all means, in order to avoid a net loss. A reinforced-concrete structure ought not to be given to such contractors at any price, however carefully supervised the work might be.

It must be confessed, however, that the owners are partly responsible for the development of bad contracting enterprises, by often awarding contracts to the lowest bidders, regardless of responsibility and competence.

All reinforced-concrete engineers will unite in doing all in their power to point out the danger to the owners and the architects. They will never insist too much on the necessity of having a reinforced-concrete structure properly designed by a competent engineer and carefully built, and by this I mean not only that the workmanship must be irreproachable but that the materials used must be of the best possible quality; for, strength of concrete lies as well in good quality of cement, cleanness and hardness of aggregates and cleanness of sand, as in careful mixture of these elements.

I must nevertheless disagree with Mr. James Ritchie in his assertion that reinforced concrete must be used for floor slabs only. A slab is but a wide beam of small depth; why then accept reinforced concrete for slabs and reject it for beams? It is logical to prohibit reinforced concrete entirely or accept it as a whole.

The columns, in the writer's opinion, are the part of a building where reinforced concrete ought to be used even if it were prohibited anywhere else, for, it is to the compression stresses that concrete has the greatest resistance. If concrete is not accepted for columns, how can it be admitted for walls? Without any doubt, after stone, concrete is the most fitted material to be used for walls.

Reinforced concrete has been extensively used in the last five years in many different types of construction and it must be universally accepted as one of the best building materials. There can be no question of limiting its use to any special part of a building, but on the contrary, its application ought to be extended to every case where strength is required.

Reinforced concrete must be submitted to regulations and careful supervision, but not be prohibited.

Yours very truly,

H. Massart.

Glenn Bldg., Baltimore, Md., Nov. 26, 1906.

The Templet System vs. Laying-Out in Bridge and Structural Shops.

Sir: There have appeared in your columns several articles on the use of templets in the fabrication of structural steel. There seems to be a difference of opinion among the various writers as to whether the modern method of complete detail plans and templets is not more costly than scratch-marking on the plain material.

Modern methods have been the outcome of increased business and the use of detail plans and templets is the red tape of the business. The whole system resolves itself into obtaining matched holes in separate pieces to be assembled for final riveting to make a complete member. System must prevail where many details are required. A small shop does not require the elaborate system of a larger one. The beauty of our modern method is the record we have of existing structures and the ease with which a structure can be duplicated.

The Engineering Department is the most natural place for making the finished details. A draftsman is a man of greater educational advantages than a shop marker who has come up from the ranks, and with proper shop knowledge should be the man to make the shop details complete. He should be familiar with the details of the shop, the methods of doing the work, and the movement of the material through the shop in the process of assembling. If easy access to the shop cannot be arranged, complete details of the locations of machines, their capacity and limitations should be known to every man in the drawing room. "Standard" books, with their instructions to draftsmen, should be made as complete as possible and with the idea that all men are beginners. A strange draftsman entering a new office is ignorant of the capacity and limitations of the machines in the shop. It is one great fault of persons compiling standards that they leave their work 50% completed.

Every shop superintendent has his own ideas as to the number of templets to be used on a job. A great deal will depend upon the shop and the kind of men employed.

The making of templets requires skilled and accurate workmen. The marking from them, however, can be done by one of less experience. Templet shops should be equipped with such power machinery as the nature of the work requires.

The greater part of the material can be marked from pole templets. On each the proper gage and spacing are shown. After they have served their purpose, they may be returned to the templet room, where the holes are plugged and the poles used as new material. It is sufficient to make templets for rivet-holes on gage lines for angles, flanges, detail plates and connections. Large-size webs which require one or more pieces in duplicate can be scratch-marked on the material and one pole be used to mark any number. This method can be used with single or multiple punches. In plate-girder work, pole templets for angles in flanges, stiffeners and splice-plates are all that is required. Gage-lines are scratched on the plates and the holes marked from the angle templets for both flanges and stiffeners.

Beams and channels with standard connections can be

plied with standards or scratch-marked as may be necessary in each individual shop. Should these shapes require a number of holes on a single gage-line, a templet will be of service. If, however, a number of beams or channels are required of the same detail, a templet will save trouble in marking. For gussets requiring but few duplications, paper templets made from heavy building paper are found to answer the purpose very well and save lumber.

There seems to be a tendency on the part of the various advocates of the two systems of doing work to make a fetish of each other's methods. Each man presents the examples of economy which will better portray his own. Neither has its good and bad qualities. System must prevail in every shop and an established system is more often the best. It is the writer's opinion that we should strike a happy medium and take the best qualities in both. No man with judgment would make a templet that would cost more than the profits on the contract. Neither would he make a templet that could be laid out with greater ease and economy on the material itself.

Complete details should be made in the drafting room. The number and kind of templets should be regulated in each shop to meet the conditions required.

The inspection of material for matching of holes in field connections is necessary and such holes as are of importance should be fitted, whether they are to be reamed holes or not.

Yours truly,

M. F. Clements, C. E..
Engineer, Clinton Bridge & Iron Works.
Clinton, Iowa, Nov. 27, 1906.

Notes and Queries.

B. A. Wise, Bradford, Pa., wishes to learn where he can procure a Sexton's "Omnimeter," a circular slide rule.

M. C. O., ——, Ontario, writes:

Our city officials wish to purchase a new stone-crusher and have asked advice as to the comparative merits of the gyratory and jaw types. We would be grateful to you or any of your readers who would inform us in what particulars the gyratory machine excels the jaw machine.

W. A. W. and B. C. write:

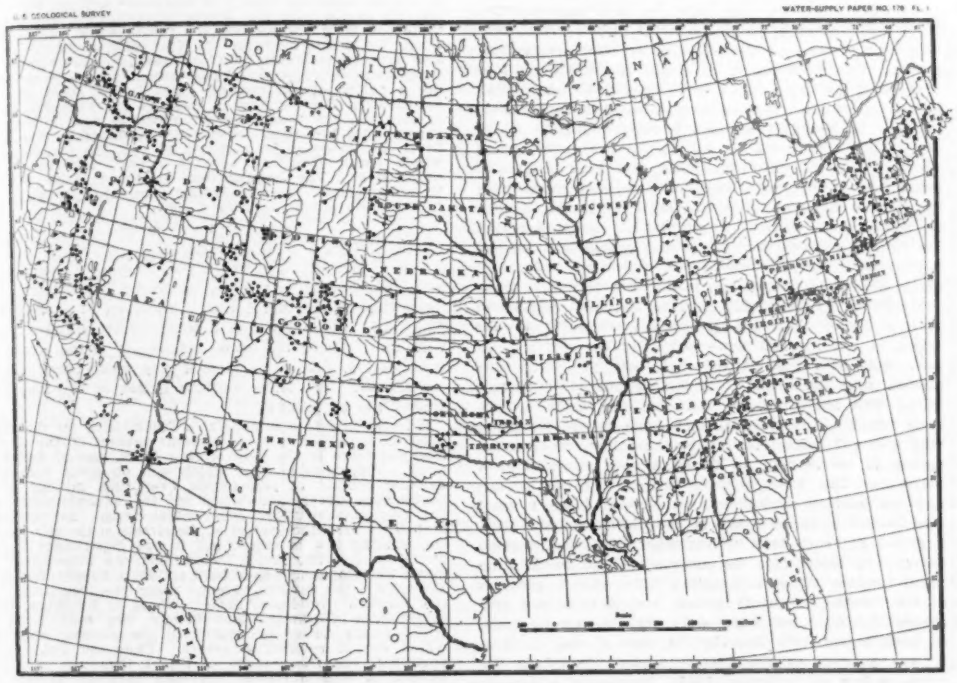
Will you kindly give us the general interpretation of the following wording of a clause in a contract for railroad work: "When the average haul exceeds 500 ft., 1 ct. per cu. yd. will be paid for each 100 ft. of excess haul."

The above refers to grading, and the question has arisen whether the average haul means that the average of the individual cuts for sections of a mile or more should be averaged up as a whole or whether each individual cut should be considered individually; the average haul being for each cut, the distance which the center of gravity of that cut is moved; or in other words, whether the word average is the average for the number of yards in each cut, or whether the average means the average of the distance which the various centers of gravity of cuts per section are moved.

We refer the question to our readers.

THE HYDROGRAPHIC WORK OF THE U. S. GEOLOGICAL SURVEY.

By an oversight, there was omitted from the editorial published in our issue of Nov. 29, 1906, a map showing the location of the 800 stream gaging stations of the U. S. Geological Survey. The map is printed herewith. The number and distribution of the stations will doubtless surprise many of our readers. As we stated in the editorial named, stream gaging is only a part of the important work done by the hydrographic division of the U. S. Geological Survey. Extensive studies of underground water have been and are being made, including the distribution of artesian areas, the movement of underground water, the cost of sinking wells and the cost of installing and operating various types of pumps. In addition, water pollution in various parts of the country is being investigated. The results of these various activities are made available quite promptly, chiefly in the very handy water supply and irrigation papers issued by the



MAP OF THE UNITED STATES, SHOWING LOCATION OF PRINCIPAL RIVER STATIONS MAINTAINED DURING 1905.

Survey, which have reached nearly two hundred in number.

This far-reaching and valuable work, as we pointed out on Nov. 29, has been threatened by opponents in Congress, who succeeded in cutting down the appropriation for 1906-7 by $50,000, thus crippling the work and necessitating its cessation at some points. If members of Congress knew the value of the gagings to engineers and others they would increase rather than diminish the appropriations for the work. We have already suggested that our readers communicate with their congressmen on this subject, either by word of mouth or by letter.

ADDITIONAL NOTES ON THE FAILURE OF THE BIXBY HOTEL, AT LONG BEACH, CAL.

Since publishing Mr. Hawgood's report on the collapse of the Bixby Hotel in our last week's issue, we have received advance proofs of "The Architect & Engineer of California" containing a report by Mr. John B. Leonard, C. E., of San Francisco, on this disaster. The following extracts from this report are of much interest in connection with the information we have already published:

The girders of the first floor are 14 ins. wide by 24 ins. deep, reinforced with three bars having a sectional area of 3.62 sq. ins. On the other floors the girders are 12 ins. wide by 18 ins. deep, and the Superintendent insists that they have the same reinforcement as on the first floor. The girders are constructed T-shape, and have 0.78 sq. in. of metal for continuity reinforcement, which projects about 3 ft. 6 ins. each side of the column center. None of the girders are provided with haunches or brackets.

The slab construction consisted of 5 × 8 ins. concrete beams placed 17 ins. c. to c. and reinforced alternately with bars having a sectional area of 0.38 sq. in. and 0.78 sq. in., respectively. Between the beams is a row of 6-in. × 12-in. hollow tile, which is placed in a line normal to the girders and parallel to the beams, the 12-in. dimension of the tile being horizontal. On top of the tile was placed a 2-in. layer of concrete which contained no reinforcement.

The columns are built of concrete and contain, usually, for reinforcement, four ½-in. round bars. In the wrecked portion, the basement columns are 21 ins. square, while those of the first story are approximately round, being about 26 ins. at the base and tapering to 22 ins. at the top. Their reinforcement consists of four ¼-in. square bars. The second story columns are 12 × 12 ins., and the third, fourth and fifth story columns are 10 × 10 ins. In some cases there was evidence of wire wrapping about 1/16-in. diameter spaced about 16 ins.; in other cases there was no evidence of wrapping whatever. In several instances some of the bars were as far as 6 ins. from the edge of the column and others only ¾-in.

The rods in the columns at the floor levels are made to abut one another by means of a gas pipe sleeve. The ruins gave evidence that in some instances even this precaution was omitted. In no case was there any evidence that reinforcement had been provided to enable the columns to transmit transverse moment to the girders and columns below. There was ample evidence that the work had been constructed by casting the column up to the elevation of the bottom of the main girders. A period of time had been allowed to elapse before the girders were fabricated. After a second interval of time, the construction of the column for the next story was commenced. This was apparent because of the smooth fractures which occurred at these places. Such reinforcement as was provided in the columns was insufficient to overcome the weakness of the lower joint and there was none at all at the floor level to safeguard the possibility of a weakness at this point.

In the wall columns, there was an eccentric condition of loading through the imposing of a 16-in. column on a 21-in. column whose outside faces were flush.

The wall construction consists of a series of concrete spandrel beams with a curtain enclosure of double 6-in. hollow tile.

The character of the concrete, where it was placed in position with precaution to insure a solid mass, was of such excellent quality that there can be no suspicion of this failure being caused by an inferior quality of cement.

In one case, I am reliably informed, such carelessness existed in the placing of the concrete as to necessitate the removal of a column after the floors and columns above had been constructed. This reconstruction was accomplished by placing two 2 × 4-in. shores underneath the girders, one each side, and closely adjoining the column. The concrete was then removed for about half the length of the column and poured anew.

The formwork appears to have been very lightly constructed, the uprights being 2 × 4 ins., ofttimes spliced midway of their length. The primary cause of the failure seems, from the best information obtainable, to have been the collapse of the formwork of the roof while the roof was being cast. The weight of the roof impinging on the fifth floor incurred a condition which the construction was unable to resist. The fifth floor was a little over two weeks old at the time of the accident. The constantly increasing load was sufficient to destroy each of the succeeding floors and to carry down with them all the interior construction.

The building was designed to carry a live load of 40 lbs. per sq. ft. The writer was unable to learn that there was any load even approximating this on the floors at the time of the accident. A calculation of the strength of the girders of the first floor in accordance with the parabolic theory shows that there would exist a fiber stress of about 11,000 lbs. per sq. in. on the steel and 400 lbs. per sq. in. on the concrete for live and dead loads. On the 10 × 10-in. columns in the third floor there existed a unit stress of about 750 lbs. per sq. in. under dead load only. Assuming the live load of the roof to have been 20 lbs. per sq. ft., there would have been a unit stress of 1,100 lbs. per sq. in. on the concrete. The building laws of San Francisco place a limitation of 450 lbs. per sq. in. on concrete under such a condition as this.

It will be well to note that an attempt in construction has been made here that is not sanctioned by the most advanced constructors, that is, the elimination of transverse girders and the placing of entire dependence for horizontal transverse forces upon thin slab construction. The entire elimination of haunches or brackets together with their reinforcement is a serious sacrifice of lateral stability, particularly so in a location where a structure may be called upon to endure very severe wind conditions.

A building having steel columns resting one on top of another with nothing more than a dowel-pin connection would inspire no feeling of security. It therefore

becomes difficult to understand why a concrete structure whose columns contain no more reinforcing material to give strength at the floor level than would be obtained in the above steel connection, should be cited as an example of failure of the reinforced concrete type. Again, imagine the designer running only a single line of girders between the above steel columns at each floor level in a five-story structure and the faults and weaknesses of the general design are apparent.

Only the opponent of reinforced concrete construction would dignify the columns of the Bixby Hotel, by classifying them as examples of this type of construction. It is true that they contain some metal, but the amount is so deficient and the placing so careless and inefficient that they can never develop the strength that columns of such dimensions should possess, and will have when properly reinforced. The defects existing in the columns would have contributed much less toward the magnitude of the disaster had the proper transverse girders been included in the construction. In fact it might reasonably be assumed that such girders would have confined the failure to a very small area and might have stopped it at the fifth floor.

The ruins of the Bixby Hotel show clearly that great care must be taken in the design and execution of such structures. They also confirm the belief that when these precautions have been taken, reinforced concrete contains the merits and security that have been advanced in its favor.

IN A SERIOUS REAR COLLISION on the main line of the Southern Railway, last week, the private car of President Samuel Spencer was telescoped and President Spencer himself was killed. The private car was wholly demolished and eight of the nine persons in it were killed. The wreck ocurred at Lawyers, a small station about 10 miles south of Lynchburg, Pa., about 6 a. m., Nov. 29. This part of the Southern Ry. is operated under a telegraphic block system. The Jacksonville express, to which President Spencer's private car was attached, left Lynchburg two hours and a half late. A defective coupling in the train gave trouble in the Lynchburg yard, and while ascending a grade between the block stations at Rangoon and Lawyers the train broke in two. Both sections came to a stop and the rear flagman, according to reports, went back immediately; but within three minutes from the time the stop occurred, a following train, the first section of the Washington and Southwestern limited, struck the rear of the standing train. According to Associated Press reports, the error which caused the collision was made by the operator in the block station at Rangoon. He passed the Jacksonville express into the block without notifying the operator at Lawyers; consequently, when a few minutes later he asked the operator at Lawyers for permission to give a clear signal to the train following, the operator at Lawyers gave the permission, not knowing of the train already in the block.

DEATHS IN THE PANAMA CANAL ZONE have been diminishing during the past few months, according to the October report of Major W. C. Gorgas, Chief Sanitary Officer. Major Gorgas says:

Our maximum was in July when we had 422 deaths. Those in September fell to 350 deaths, and during October there has been a still further fall to 302 deaths. This difference has been almost entirely due to the decrease in pneumonia. Between the months of September and October, we had a drop of 48 in the total number of deaths. In deaths from pneumonia between those same months we had a drop of 38 deaths.

The same decrease in death rate is noticed among our employees. In September we had 135 deaths, in October, 99, a decrease of 36 deaths. This decrease is due principally to the decrease in pneumonia. There were 59 deaths from pneumonia during September and only 34 in October. A decrease of 25.

Of the 5,500 whites on the rolls, only two died from disease. Of the 19,000 negroes, 86 died from disease.

Of our 6,000 Americans, including women and children, none died from disease.

A TYPHOID FEVER OUTBREAK at the University of South Carolina (Columbia) has just occurred and is attributed to temporary use of a well while the city water supply was cut off. Of 11 cases of typhoid reported among more than 300 students, all were confined to those students who took their meals at the "mess hall," 130 in number. On Oct. 2 the city water was cut off from the mess hall, on account of its turbidity, and on Oct. 3 and 4 water from a well in a near-by street was used. On Oct. 16 a case of typhoid fever was admitted to the college hospital, and on Oct. 19, 20 and 22 one case additional for each day was admitted. On Oct. 15 the water main supplying the mess hall was broken by workmen trenching for a telephone company, again cutting off the supply, and on Oct. 17 the water supply of the whole city was cut off by a break in the reservoir supply main; so that from Oct. 15 to 19 the well water was again used. On Oct. 26 two more cases of typhoid were admitted to the hospital, and one case was admitted per day for Oct. 27, 30 and 31, Nov. 2 and Nov. 6. After Nov. 6 no cases had developed up to Nov. 16, on which date a special report on the outbreak was made by Dr. C. F. Williams, the Board of Health physician of the City of Columbia (see Charleston "News and Courier," Nov. 17, 1906). In his report Dr. Williams states that the milk supply at the university was above suspicion, the dairy from which the milk comes being owned and operated by the university and everything connected with it being "conducted in the most sanitary manner." The food supplies for the mess hall "are bought in open market, and as there is practically no typhoid fever in the city this possible source of infection can also be eliminated." Investigation showed no cases of typhoid near the mess hall, from which contamination of food by flies could have occurred. At the time the report was made, nothing had been discovered to thrown suspicion upon the well; or at least the report contains no hint of such a discovery. A report on an analysis of the water was expected soon.

TYPHOID FROM POLLUTED WATER occurred in such amount in the City of Detmold, Germany, in the fall of 1904, as to constitute an alarming epidemic. The epidemic was investigated for the German Government by Drs. M. Beck and M. Ohlmüller, whose report was published recently. An abstract of this report, in the "Gesundheits-Ingenieur" of Oct. 6, 1906, gives the following facts. The source of the infection was indicated by the sudden spread of the disease, its uniform distribution, the immunity of houses supplied from their own wells, the fact that the milk supply comes from many different points, etc., all pointing unmistakably to the water-supply. The water comes from three springs, five miles away, developed in 1899 by a concrete-lined gallery, closed and ventilated. A conduit carries the water to a sedimentation basin, and thence it flows to a high-level supply reservoir, from which the supply line leads to the city. The investigation showed that the infection could not have originated below the springs, and that, as the latter were protected from direct pollution, the fault lay in the springs, or rather their feeders, if anywhere. It appears that the valley in which the springs are located is a popular outing-place, and that its soil is very open and shows many pits or cave-ins, apparently due to scour below the surface; as these pits all face the point where the springs issue, they are probably attributable to the action of underground flows supplying the springs. In fact, tests with salt showed that these pits have connection with the springs. A further possibility of pollution was found in the fact that the three springs from which the supply is taken have water connection with a fourth spring, farther up the valley, which latter spring is so located as to be always susceptible of pollution. The close relation between all the springs and the surface run-off was demonstrated by a great rise in the bacterial count of the spring water during a period of heavy rain in November, 1904, and a rapid decrease in bacteria as the surface flow decreased. During November some construction work was in progress at the fourth (not used) spring, and it is known that among the workmen were some typhoid convalescents, of such recent date that in the case of one of them it was possible to demonstrate typhoid bacilli in the urine as late as December, 1904. Samples of soil taken from the immediate neighborhood of the fourth spring, and of sand collected near the site of working, showed typhoid germs [it is said]. These facts are held to establish a very great probability that this neighborhood was the source of infection. While it may be thought remarkable, under this view, that no second epidemic occurred although the typhoid evidences mentioned were found during the investigation, after the epidemic in the city, it is held that the fact may be explained by an acquired immunity of the inhabitants of the city, developed by the first epidemic. For future protection of the supply the investigators recommend ozonization, preferably preceded by rapid filtration.

DEATHS FROM TYPHOID FEVER AND DIARRHEAL diseases in Chicago for 82 months before and 82 months after the opening of the drainage canal (March, 1893, to December, 1899, and January, 1900, to October, 1906, inclusive) have been as follows, according to the Bulletin of the Department of Health of Chicago for Nov. 24, 1906:

	Period		Reduction	
	First.	Second.	Actual.	Per cent.
Typhoid fever:				
Total deaths.....	3,874	3,238	636	16.4
Rate per 100,000 of population	38.6	24.7	...	36.0
Ratio to total deaths from all causes..	2.4	1.8	...	25.0
Diarrheal diseases:				
Total deaths.....	19,792	16,069	3,723	18.8
Rate per 100,000 of population	197.3	122.5	...	37.0
Ratio to total deaths from all causes..	12.0	8.8	...	26.7
All impure-water diseases:				
Total deaths.....	23,666	19,307	4,359	18.4
Rate per 100,000 of population	235.9	147.2	...	37.6
Ratio to total deaths from all causes..	14.4	10.6	...	26.4
All causes:				
Total deaths.....	164,262	182,223	...	....
Rate per 1,000 of population	16.38	13.89	...	15.2
Population:				
Yearly average....	1,506,744	1,969,543	...	*30.7

*Increase.

AN INSPECTION OF IRRIGATION WORKS being carried out by the U. S. Reclamation Service has just been made by Mr. F. H. Newell, M. Am. Soc. C. E., Chief Engineer. The following statement regarding labor conditions on these works and in the Far West generally, and also regarding progress on one or two important dams, will doubtless be of interest to many of our readers:

In general the work is progressing favorably, and construction has reached a point where results can be seen. The chief drawback at the present time is the difficulty of securing competent laborers. Men who can be had for this western work are, as a rule, restless and rarely stay more than a few days or weeks at any one point. They travel from job to job, staying just long enough to get well fed and accumulate a few dollars, then leave for the next place. The large amount of railroad construction, as well as the number of contracts under way with the Reclamation Service, make it possible for laborers to strike a new job wherever they stop. A contractor having on an average 1,000 men at work will have on his pay roll for the month from 2,000 to 3,000 names. There is a small army of laborers tramping backwards and forwards along each railroad line, the greater part at present being headed, of course, for California and the Southwest in general. The difficulty in obtaining and holding good labor and the increase in the cost of materials have resulted in putting out of business a number of small contractors and subcontractors, especially those who took their contracts six months or a year ago. The outlook for the future is also so uncertain that it is extremely difficult for contractors to bid with any degree of confidence, and hence there are very few proffers for future work. This condition holds not only for the Reclamation Service, but also for the railroads. On one extension four different contractors in succession have thrown up the work during a period of six months. The largest work of the Reclamation Service now in hand is the Roosevelt dam in Arizona, the foundation of which is now in and is approaching the river level. If the floods in the Salt River do not occur for a month or two, the foundations, which cover about an acre in extent, will be above water level. The Laguna dam on the Colorado River, 12 miles above Yuma, is being successfully pushed by J. G. White & Co., of New York.

THE STREET ADMINISTRATION OF NEW YORK City is to be investigated by a Commission, in accordance with recommendations made to Mayor McClellan by a committee of the Merchants' Association of New York City. The mayor has sent a letter to five eminent New York men, stating the cause and objects of the proposed investigation, and asking them if they would serve on the commission. The letter and the names of the men addressed are as follows:

It is my intention to appoint a Commission for the purpose of enquiring into the present system of the street administration in the City of New York, and of devising some comprehensive plan which will do away with the existing conflict of jurisdiction over such matters, and concentrate the responsibility for the administration of the city streets under one central head. As you are probably aware, the control of the streets of the city under the existing law is vested not in one department alone, but in many. The Police Department, the Department of Street Cleaning, the Department of Water Supply, Gas and Electricity, the various bureaus under the jurisdiction of the Borough Presidents, namely, those of Buildings, Encumbrances, Highways and Sewers, are each charged with certain duties in regard to the streets, some of which are of conflicting nature. Thus the Police Department, the Department of Street Cleaning, and the Bureau of Encumbrances, are each required by law to remove obstructions from the streets; while the Bureau of Buildings is permitted to grant permits for their partial occupation during building operations. The Department of Water Supply, Gas and Electricity, and the Bureau of Sewers have the right to allow the surface of the streets to be opened, while the Bureau of Highways is charged with the duty of keeping the surface of the streets in repair. In addition, the public service corporations claim certain rights to open up and disturb the surface of the streets for various purposes, after the exercise of which it is often difficult to obtain from them a speedy and satisfactory restoration. As the result of this divided responsibility, a street is often allowed to remain in a deplorable condition, while it is impossible to call on any one department to account for its existing condition. For example, if the Police Department, or the Department of Street Cleaning, proceeds to remove building material that is unnecessarily obstructing the traffic on a street or a sidewalk, the defense is offered that such an obstruction has been permitted by the Bureau of Buildings. If it is sought to hold the Bureau of Highways responsible for the condition of a pavement, the answer is made that the bureau is powerless to proceed, because the openings have been ordered and continued by the Department of Water Supply, Gas and Electricity or the Bureau of Sewers.

The continuance of these conditions should not longer be tolerated by the city. In my opinion a better administration of our streets can be readily effected by abolishing all such conflicting jurisdiction, and by concentrating the responsibility for street maintenance under some one central authority. It should be the duty of this commission, which I propose to appoint, to investigate the administrative methods now in force, and to suggest a plan of reorganization through which the city may obtain an efficient system for keeping its streets in the condition demanded by public safety and convenience.

My purpose in writing you at length concerning this matter is to ask whether you will accept an appointment as a member of this proposed commission.

Yours very truly,

(Signed) Geo. B. McClellan, Mayor.

To: John C. Eames, Vice-President of The H. B. Claflin Co. and Chairman Committee on City Conditions, The Merchants' Association.

Nelson P. Lewis, Chief Engineer, Board of Estimate and Apportionment.

William C. Redfield, Ex-Commissioner of Public Works, Borough of Brooklyn.

Samuel Whinery, Author of "Municipal Public Works, Their Conception, Inception and Management." Has served as consulting engineer in certain matters for the Department of Docks, and the President of the Borough of Manhattan.

Walter C. Kerr, President of Westinghouse, Church, Kerr & Company, engineers.

Messrs. Eames, Lewis, Redfield and Kerr were recommended for appointment on this commission by The Merchants' Association of New York.

A NEW TEMPORARY STATION AT THE GRAND Central to be used about three years was recently opened by the New York Central R. R. Co. in the basement of the Grand Central Palace at 43d St. and Lexington Ave. This change was made necessary by the tearing down of the train-shed annex in 42d St. preparatory to the construction of the large new terminal station to be built there. Fourteen tracks with third rails, ten of which are to be used at once, have been run from the switching yards into the basement level, where train-sheds have been constructed. On the ground floor is a waiting room, ticket offices, information bureau, telephone and telegraph offices, and all facilities of a permanent railway station. Staircases numbered to correspond with the tracks connect the ground floor with the basement, and gates regulating entrance to the trains are placed at the top of the stairs. To prevent crowding at the gates a wide corridor has been built between the stairs and the waiting room, with side exits in Lexington Ave.

A CAVE-IN OF QUICKSAND at Claremont Park, Morris Ave. and 172d St., New York City, Nov. 27, killed two laborers and injured several others. The men were engaged in digging a sewer trench, which at this point had reached a depth of about 75 ft. The excavation was lined with heavy planks to prevent cave-ins, but the pressure became so great that this planking was broken, thus allowing the sand to pour in on the men.

AN EXPLOSION OF ROBURITE, a high-power explosive, at Annen, Germany, Nov. 28, killed 40 persons and fatally injured 38 others, some 200 persons, all told, being injured. The explosion occurred in a roburite factory and, according to press reports, the concussion was felt for a radius of eight miles, while many persons were totally deprived of their hearing by the bursting of their ear drums. The damage is estimated at $500,000.

THE NUMBER OF TRAINS AT CHICAGO, entering and leaving the several stations during the day, is given by the "Travelers', Shippers' and Mail Guide" as follows: Through passenger and mail trains, 458; suburban trains, 807; freight trains, 272; total, 1,537. These figures are for 35 different railways. The Chicago & Northwestern Ry. has by far the largest number of through passenger and freight trains, 78 and 58 respectively; its record of 220 suburban trains, however, is exceeded by that of the Illinois Central Ry., with 251 trains. Ranking next in the list are the Chicago, Milwaukee & St. Paul Ry. with 55 through passenger trains daily; the Chicago, Rock Island & Pacific Ry. with 91 suburban trains; and the Illinois Central Ry. with 24 freight trains per day.

THE ELECTRIC RAILWAYS of the United States at the end of 1905 aggregated 32,517 miles of track (including elevated railway), with 63,391 motor cars and 13,059 trail and service cars. Cable, steam dummy and horse lines aggregated only 633 miles, with 1,084 grip cars or locomotives and 2,217 trail or horse cars. The total capital stock was $1,844,565,136.

A FORM OF BRAKE RIGGING designed to give a maximum pressure of the brakeshoe upon the wheel at high speed, and to reduce the pressure as the speed is reduced, so as to maintain a uniform coefficient of friction between the brakeshoe and the wheel, is being tried on the Northwestern Ry. of England. It is regulated by the movement of the brakeshoe due to the friction against the wheel. It is being introduced by the Maximus Brake Syndicate, of London, England.

PRECAUTIONS TO BE OBSERVED IN ENTERING sewers seem to give more concern in England than in America. This may be due to the fact that many of the sewers there are older and therefore in poorer condition than in this country, and also to the fact that the small amount of sewage per capita renders the sewer air more dangerous in England than here. In "The Local Government Officer" for Nov. 17, 1906, there is published a circular of instructions on this subject by Mr. J. Corbett, Borough Engineer of Salford, England, as follows:

Directions for Dealing with Foul Gas in Sewers.

The District Surveyors are requested to hand copies of these directions to their Foremen and to see that the precautions here described are duly observed in all sewer works under their charge.

Whenever men have to go down into an old and foul sewer or cesspool the following precautions must be taken:

(1) Open the lids of two adjacent manholes so as to provide a downcast and an upcast shaft; or if only one manhole is available and there is no other outlet by an open sewer or vent-pipe, place a wooden tube about a foot square down the one manhole for use as a downcast shaft.

(2) Use one manhole or the wooden pipe above described as a downcast shaft, by means of a heavy shower of water from a large watering can with a rose jet, or else from a rose jet on a hose pipe from the town's water mains.

(3) Where there are two manholes near together, use one for the downcast shaft, by means of the shower of water above described; and use the other for the hoisting and working shaft.

(4) Test the air in any shaft before men go down it by lowering a lighted candle down it. If the light burns dull, even without going out, the shaft must not be entered. Ventilate the shaft as before described and test it again, and do not enter it until a light will burn brightly in it.

(5) Beware of any mixture of combustible or explosive gas in the sewers or their manholes, and if any signs of such gases are found, obtain skilled men and safety lamps from some colliery, and let those men direct the work, giving them the help of ventilation, etc., as before described.

(6) When a man has to descend a risky manhole or shaft, he must have a strong rope properly tied about his shoulders, so that he could be lifted by it, and the ropes must be kept in hand ready to lift him up if he becomes overpowered by the gas.

When a man has to crawl along a risky sewer he must have a short rope securely tied to his ankles and a rope from it to hand so as to draw him back if he becomes overpowered by the gas.

(7) In any case of special difficulty or danger, report the case immediately to the Borough Engineer, so that he may take the responsibility of the work.

THE LAKE AND GULF DEEP WATERWAY ASSOCIATION has been organized at St. Louis, as the result of a waterway convention. The President is W. K. Kavanaugh, and the Secretary, Wm. F. Saunders, both of St. Louis. The convention adopted a resolution in favor of a waterway with a minimum depth of 14 ft. from the Chicago Drainage Canal through the valleys of the Desplaines and Illinois Rivers and down the Mississippi River to St. Louis, but recommended that in view of future needs the locks should be made with a minimum depth of 21 ft. on the sills. The cost is estimated by the U. S. Engineers at $31,000,000. The resolution also declared that in conjunction with the prosecution of the deep-water enterprise northward from St. Louis, provision should be made by Congress for such work on the lower river as to give permanence to the channel and stability to the caving banks.

STREET WIDENING AND IMPROVEMENT in London, England, is being undertaken by the London County Council for the improvement of main routes of traffic which now consist largely of narrow streets that are not in direct line with each other. The important work of this kind in the construction of the new streets, Kingsway and Aldwych, was recently described in our columns, and the Strand (one of the most traveled streets of London) has been widened. Along Mare St. (Hackney) the buildings on the east side have been torn down, the street widened, and a number of new buildings have already been erected. The Council has also decided to build a new thoroughfare through the congested district between the Tower Bridge and Great Prescott St. (Stepney); this will cost about $1,500,000, and in addition to this the city will spend about $527,500 in other improvements in connection with this work. In a number of other cases, main streets are being widened and straightened, and new streets cut through densely populated and congested sections.

TWO ELECTRO-PNEUMATIC INTERLOCKING plants are to be installed by the Union Switch & Signal Co. at the new Union Terminal Station, Washington, D. C. These two machines aggregate 210 working levers for the control of 282 signals, 74 single switches and 41 sets of double slip switches with movable point frogs. The signals will be three-position, operating in the upper quadrant, and electrically lighted. All high signals will be semi-automatic in their control. No detector bars are to be installed; the switch levers being locked in the machine through the medium of track circuits. Storage batteries will be used exclusively—energizing the track circuits (of which there are 200), as well as the interlockings proper. A means of communication between the tower director, conductors and gatemen is also to be provided, the indications being given by specially designed light signals.

CONCRETE BLOCKS FOR TUNNEL LINING on the Mexican Central Ry. were described in our issue of July 26, and similar blocks are to be used for the arch lining of the Arthur's Pass tunnel on the Midland Ry. extension of the New Zealand Government Railways. The tunnel will be 28,062 ft. long, with a width of 15 ft. and a height of 15 ft. 6 ins. above the rails. The sides are of 15 ft. radius and the arch is of 7 ft. 3 ins. radius. The specifications provide that the walls may be of concrete (12 ins. thick), brick (14 ins.), or rubble masonry (16 ins.). The concrete blocks for lining the arch will be 12 ins. thick, 18 ins. long, and 9 ins. wide on the soffit face, bonded to break joint as in ashlar masonry. For extra thickness, 18 ins. and over, two or more rings of blocks 9 ins. thick may be used. The blocks must be left in the molds for at least 24 hours, then laid out on platforms and finally stacked, being wetted at intervals. They must not be put into the work until at least 50 days old. The concrete is to be composed of Portland cement, sand and broken stone, 1 to 2 to 5; half of the stone must not exceed 1½ ins. and the remainder must be of smaller assorted sizes.

PERSONALS.

Mr. Frank L. Chase has resigned as President and General Manager of the Jamestown, Chautauqua & Lake Erie Ry.

Mr. L. E. Golden, Chairman; Mr. John C. Cook, Secretary, and Mr. G. A. Pearce, have resigned as members of the Water Commission of Columbus, Ga.

Mr. Frank L. Casey has been appointed Assistant Superintendent of the Traffic Department of the Elmira Water, Light & Railroad Co., of Elmira, N. Y., to succeed Mr. Edwin S. Becker, resigned.

Mr. W. T. Leeke has been elected President of the San Antonio Water Co., of Ontario, Cal. Mr. E. H. Jolliffe has been made Vice-President and Mr. J. N. Hartley, Temporary Secretary.

Mr. James P. Gaffney, Chief Engineer of the George's Creek & Cumberland R. R., has resigned to become Chief Engineer of the General Contracting & Engineering Co., of New York City.

Mr. John A. McIlhenny, of New Iberia, La., has been appointed a Member of the U. S. Civil Service Commission, to succeed Mr. Alfred W. Cooley, recently appointed Assistant Attorney-General of the United States.

Mr. A. C. Spencer, for 11 years General Foreman of Construction for the National R. R. of Mexico, has resigned to accept the position of Superintendent of Construction for MacKinzie, Mann & Co., Ltd. Mr. Spencer will have charge of the constructiin of the Monterey, Mex., sewer and water-works, and also the Electric Street Railway Co.'s lines.

Mr. Allen Hazen, M. Am. Soc. C. E., of Hazen & Whipple, Consulting Engineers, 220 Broadway, New York City, will sail from Vancouver, B. C., on Dec. 7, for Brisbane, New South Wales. He will be absent from New York about three months, during which time he will make an examination and report on the water supply of that city. The present supply is partly from a highly turbid river and partly from impounding reservoirs, which give rise to troubles from micro-organisms.

The following changes have taken place in the Reclamation Service: Messrs. Henry R. Evans, Assistant Engineer on Sun River Project, Mont., and A. C. Hansen, Engineer on Yuma Project, Ariz., have resigned from the Service; Mr. Lewis P. Abell has been appointed Draftsman and assigned to Williston Project, N. Dak.; Messrs. Henry W. Bashore and Carroll A. Farwell have been appointed Engineering Aids and assigned to duty on the Interstate Canal, Neb., and with Mr. B. M. Hall, Supervising Engineer, El Paso, Tex., respectively.

Mr. Henry Harrison Suplee, M. Am. Soc. M. E., for many years Technical Editor of the "Engineering Magazine," and Mr. James Van Vorst Colwell, M. Am. Soc. M. E., recently Works Manager of the C. H. Hunt Co., have bought "Cassier's Magazine," from the estate of the late Louis Cassier, and will continue its publication, as heretofore, under the firm name of Cassier Magazine Co., 3 West 29th St., New York City. Mr. Suplee will act as editor, while Mr. Colwell will attend to the business end of the concern. The first issue of the magazine under the new management will be the January number.

Obituary.

G. B. Nicholson, M. Am. Soc. C. E., Chief Engineer of the Queen & Crescent Route, died, Dec. 2, at Covington, Ky.

John R. Perkins, President of the Riverhead Electric Lighting Co., Riverhead, L. I., died at his home there, Nov. 27, aged 73 years.

Richard E. Emory, General Manager of the San Jose & Santa Clara Ry., died at San Jose, Cal., Nov. 24, of acute indigestion, aged 36 years.

James Dickson Hunter, for more than 20 years connected with the firm of McKim, Mead & White, Architects, New York City, died at his home in Yonkers, N. Y., Nov. 28, of heart disease, aged 49 years. Mr. Hunter was a member of the Architectural League of New York.

Gen. L. Victor Baughman, President of the Chesapeake & Ohio Canal, died at his home in Frederick, Md., Nov. 30, of Bright's disease, aged 63 years. He served in the Confederate army during the Civil War and was Chairman of the Commissioners of the Louisiana Purchase Exposition, in 1904.

William Allen, President of the William Allen & Sons Co., Proprietor of the Worcester Steam Boiler Works, of Worcester, Mass., died at his home in that city, Nov. 27, of heart disease, aged 81 years. Mr. Allen moved to Worcester in 1849, where he engaged in various lines of machine and mechanical business until 1872, when he established the large boiler works, with which he had since been identified.

Charles Humphreys, M. Am. Soc. C. E., Assistant Engineer, U. S. Engineering Department, died at his home in Washington, D. C., Nov. 18, of stomach trouble, aged 54 years. Mr. Humphreys was for nearly 20 years Assistant U. S. Engineer at Wilmington, N. C., but was transferred to Wheeling, W. Va., in 1901. Three years later he was transferred to Mobile, Ala., where he remained until six months ago, when he was forced to return to his home in Washington for medical treatment.

Arthur Vaughan Abbott, Chief of the Statistical Department of Westinghouse, Church, Kerr & Co., died at New York City, Dec. 1, of pneumonia, aged 52 years. Mr. Abbott was born at New York and was a member of the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the American Institute of Mining Engineers. He was formerly Chief Engineer of the Chicago Telephone Co., but had been connected with the Westinghouse Company since 1902. Mr. Abbott was the author of several books and technical articles, among them being "Electrical Transmission of Energy," "History and Use of Testing Machines," etc.

George L. Bradbury, formerly Vice-President and General Manager of the Lake Erie & Western R. R., died at his home in Chicago, Ill., Nov. 30, aged 63 years. He was born at Yarmouth, N. S., but emigrated to this country and served through the Civil War, retiring with the rank of Colonel. He then entered the railroad business and became General Manager of the Peoria, Lincoln & Decatur R. R., now a part of the Illinois Central R. R. In March, 1882, he became General Manager of the Michigan & Ohio R. R. and was made Vice-President of the Toledo, St. Louis & Western R. R. in 1886. Mr. Bradbury was elected Vice-President and General Manager of the Lake Erie & Western R. R. in 1887, remaining in that position until 1900, when he retired from active business.

Sir Edward James Reed, M. Inst. C. E., formerly Chief Constructor of the British Navy, is dead. He was born Sept. 20, 1830, at Sheerness, Kent, and was educated at the School of Mathematics and Naval Construction at Portsmouth. He was at one time Editor of "The Mechanics' Magazine," and was appointed Chief Constructor of the Navy in 1863. He held this position for seven years, when he resigned because he did not favor rigged seagoing turret ships, which were then much in favor. From 1874 to 1895 he was a Member of Parliament, and was made Lord of the Treasury in 1886. Sir Reed was the author of several books and articles on ships and shipbuilding, among which were: "The Stability of Ships" and "Modern Ships of War." He was Vice-President of the Institute of Naval Architects and a former member of the Council of the Institution of Civil Engineers.

Samuel Spencer, President of the Southern Ry., was killed in a rear collision on the Southern Railway near Lynchburg, Va., Nov. 29. President Spencer with a party of friends, including Gen. Philip Schuyler, of New York, and Messrs. Charles D. Fisher and Francis T. Redwood, of Baltimore, Md., were en route, in President Spencer's private car, to Greensboro, N. C., where they expected to do some quail shooting. All these gentlemen were instantly killed by the collision. Mr. Spencer was born at Columbus, Ga., Mar. 2, 1847, and when the Civil War broke out he enlisted in the Confederate Army as a private. At the close of the war he decided to be a civil engineer and entered the University of Georgia, graduating in 1867. He then entered the University of Virginia, from which institution he was graduated in 1870 at the head of his class.

His first position after leaving college was as a rodman on a surveying party of the Savannah & Memphis R. R. He was, however, quickly promoted through the grades of leveler, transitman and resident engineer to Principal Assistant Engineer. Wishing to learn the technicalities of the operating end of the railroad business, he accepted the position of Clerk to the Superintendent of the New Jersey Southern R. R. at Long Branch, N. J., in 1872. Shortly afterwards he became Assistant Supervisor of Trains on the Baltimore & Ohio R. R., being promoted to Chief Supervisor in May, 1873. In 1877 he was made Superintendent of the Virginia Midland R. R., a road that was later absorbed by the Southern Railway, and it was on this division of the Southern that he met his death.

The next year he left this railroad to become General Superintendent of the Long Island R. R. He was appointed Assistant to the President of the Baltimore & Ohio in 1879, becoming Acting General Manager of the Trans-Ohio Division of that road in 1881. He was elected Third Vice-President of the Baltimore & Ohio R. R. in 1882, Second Vice-President in 1884, First Vice-President in 1887, and President in December of the same year.

In the latter part of 1888 Mr. Spencer accepted the position of Railroad Expert for the well-known banking firm of Drexel, Morgan & Co., now J. P. Morgan & Co. He remained with this company until June, 1894, when he was elected President of the Southern Railway. While still connected with the banking firm, Mr. Spencer was elected President of the Elgin, Joliet & Eastern R. R. of Illinois, in 1889, and in 1893 was appointed receiver of the Richmond & Danville R. R. and the East Tennessee, Virginia & Georgia R. R. He was also a member of the first New York Rapid Transit Commission and served the city from 1891 to 1893. At the time of his death Mr. Spencer was also President of the following roads: The Cincinnati, New Orleans & Texas Ry.; the Alabama Great Southern Ry.; the Georgia Southern & Florida Ry., and the Mobile & Ohio R. R., besides being a Director of the Central of Georgia Ry.; the Chicago, Milwaukee & St. Paul Ry.; the Erie R. R.; the Northern Pacific Ry., and others.

Mr. Spencer was married in February, 1872, to Miss Louise Vivian Benning, of Columbus, Ga., and is survived by her and three children: Mr. Henry B. Spencer, General Manager of the Southern Ry.; Miss Vivian Spencer and Mrs. James D. Long.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Dec. 3-7. Annual Meeting at Mexico City, Mexico. Secy., Chas. O. Probst, M. D., Columbus, Ohio.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 4-7. Annual Meeting at New York City. Secy., F. R. Hutton, 12 West 31st St., New York, N. Y.

ENGINEERING ASSOCIATION OF THE SOUTH.
Dec. 14-15. Annual Meeting at Atlanta, Ga. Secy., H. M. Jones, 2 Berry Blk., Nashville, Tenn.

AMERICAN ECONOMIC ASSOCIATION.
Dec. 26-28. Nineteenth Annual Meeting at Providence, R. I. Secy., Mr. Winthrop M. Daniels, Princeton, N. J.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 27-Jan. 2, '07. Annual Meeting at New York City. Secy., L. O. Howard, Cosmos Club, Washington, D. C.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.
Jan. 3. Annual Meeting at Pittsburg, Pa. Secy., F. V. McMullin, 410 Pennsylvania Ave., Pittsburg, Pa.

THE AMERICAN INSTITUTE OF ARCHITECTS.
Jan. 7-9. Annual Convention at Washington, D. C., Secy., Glenn Brown, Washington, D. C.

MICHIGAN ENGINEERING SOCIETY.
Jan. 8. Annual Convention at Detroit, Mich. Secy., F. Hodgman, Climax, Mich.

NATIONAL ASSOCIATION OF CEMENT USERS.
Jan. 8-11. Annual Meeting at Chicago, Ill. Secy., W. W. Curtis, 585 Caxton Bldg., Chicago, Ill.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Jan. 9. Annual Meeting at Boston, Mass. Secy., Mr. Willard Kent, Narragansett Pier, R. I.

WOOD PRESERVERS' ASSOCIATION.
Jan. 15. Annual Meeting at Memphis, Tenn. Secy., C. W. Berry, Laramie, Wyo.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 16-17. Annual Meeting at New York City. Secy., C. W. Hunt, 220 West 57th St., New York.

INDIANA ENGINEERING SOCIETY.
Jan. 17-19. Annual Meeting at Indianapolis. Secy., C. C. Brown, Commercial Club Building, Indianapolis, Ind.

THE ENGINEERS' CLUB OF PHILADELPHIA.
Jan. 19. Annual Meeting at Philadelphia. Secy., Walter Loring Webb, 1122 Girard St., Philadelphia, Pa.

CANADIAN SOCIETY OF CIVIL ENGINEERS.
Jan. 29. Annual Meeting at Montreal. Secy., Prof. C. H. McLeod, 877 Dorchester St., Montreal, Quebec.

THE NATIONAL BRICK MANUFACTURERS' ASSOCIATION.
Feb. 4-16. National Convention at St. Louis, Mo. Secy., Theo. A. Randall, Indianapolis, Ind.

NEW ENGLAND GAS ASSOCIATION.
Feb. 21. Annual Meeting at Boston, Mass. Secy., N. W. Gifford, East Boston, Mass.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 23-25. Annual Meeting at Peoria, Ill. Secy., E. E. R. Tratman, 1636 Monadnock Block, Chicago, Ill.

ASSOCIATION OF ONTARIO LAND SURVEYORS.
Feb. 26. Annual Meeting at Toronto. Secy., Killaly Gamble, 405 Temple Bldg., Toronto, Ont.

WESTERN SOCIETY OF ENGINEERS.—At a special meeting held at the society's rooms, in Chicago, on Nov. 26, a paper on "Practical Pyrometry" was read by Mr. Robert S. Whipple, Vice-President of the Cambridge Scientific Instrument Co., of Cambridge, England. The paper dealt with the different forms of thermometers and pyrometers for measuring high and low temperatures, and was illustrated by a number of lantern slides. Examples of the instruments and apparatus were shown, and a high-temperature electric furnace was exhibited in operation, with pyrometers and recording instruments connected up to it.

WISCONSIN ELECTRIC & INTERURBAN RAILWAY ASSOCIATION.—This new association has been organized for the discussion of matters relating to the construction and operation of electric railways and properties, and for the acquisition of knowledge and information concerning similar matters. The membership consists of companies operating electric properties in Wisconsin, and the officers are as follows: President, Henry D. Smith, Wisconsin Traction, Light, Heat & Power Co., Appleton, Wis.; Vice-Presidents, Thomas Higgins, Herbert Warren and F. W. Montgomery; Secretary and Treasurer, Clement C. Smith, Columbia Construction Co., Colby & Abbot Building, Milwaukee, Wis.

AMERICAN ELECTROCHEMICAL SOCIETY.—A meeting of the New York Section of the society, for the election of officers, etc., will be held Tuesday, Dec. 11, at 8.30 p. m., at the Chemists' Club, 108 West 55th St., New York City. After the business session, Mr. Van Rensselaer Lansingh will deliver a lecture on "Illumination," illustrated by lantern slides. Mr. Lansingh will discuss loss of light by common methods; effect of light on the eyes; methods of measuring light; how light can be modified in its distribution; the practical consideration of problems of lighting; modern illuminants; carbon filament; tantalum filament; metallized filament; tungsten lamp; Nernst lamp; flaming arc; Cooper-Hewitt lamp and the Moore tube.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.—The Committee on Fences, Crossings and Cattleguards has issued a circular regarding practice in regard to (A) Gates and posts for right-of-way fences, (B) Construction and protection of highway grade crossings, (C) Metal and wooden track signs and posts. The Committee on Yards and Terminals has issued a circular of enquiry in regard to practice in the details of the lay-out of freight yards for hump or gravity switching, and the methods of lighting such yards; also as to the design of terminal freight houses and freight transfer houses, with recommendations for freight-handling machinery in houses of this character. Information should be sent to Mr. E. H. Fritch, Secretary of the Association, 962 Monadnock Block, Chicago.

AMERICAN INSTITUTE OF ARCHITECTS.—The next convention of the institute will be held at Washington, D. C., Jan. 7-9. It will commemorate the fiftieth anniversary of the institute, founded in 1857, and a bronze tablet, containing the names of the founders, will be unveiled in "The Octagon," the home of the institute, to commemorate the occasion. The institute will also inaugurate at this meeting the custom of presenting a gold medal for distinguished merit in architecture. This first medal will be presented to Sir Aston Webb, the architect of the Victoria Memorial, London, who received the gold medal of the Royal Institute of British Architects and knighthood during the past year. Routine business, ceremonial and social events will occupy the time of the delegates and no formal papers will be read.

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.—On Tuesday, Nov. 27, over one hundred members of the society through the courtesy of Chief Engineer Bush, of the Delaware, Lackawanna & Western R. R., made an inspection tour of the construction work now being done on the Lackawanna lines near New York City. The party assembled at the West 23d St. Ferry Station, New York City, at 10.30 a. m., and after examining that new station, crossed the river to the Hoboken terminal. (Eng. News, Sept. 20, 1906, p. 297). The low, open-roofed train sheds at the Hoboken terminal (the design of Chief Engineer Bush) proved very interesting. By providing an open roof and thus freeing the sheds from steam and smoke, the metal work is largely freed from the corrosive action of the locomotive gases. Therefore, less painting is required and at the same time the first cost and maintenance charges are less than in the high closed sheds. The platforms are also better ventilated and lighted.

From Hoboken, the party proceeded by special train to Newark, where luncheon was served at the Continental Hotel. After luncheon the grade crossing eliminations through Newark and Summit were visited, as well as the inclined plane at Roseville. This inclined plane, or ship railway, has proved of much value in the solution of many grade crossing problems incident to the operation of the Morris Canal. At seven different points along the Lackawanna lines these inclined planes are employed to transport canal boats across the railroad. They are laid on a 10% grade, the carriages being lifted by cables operated by 100-HP. electric motors. The canal boats (100 ± tons) as well as the carriages are hinged at the center, to facilitate their passing the summit. At Roseville about 150 crossings are made per month. The level of the water in the canal is maintained by a 6-ft. siphon laid beneath the bed of the railroad.

From Roseville the party proceeded to the shops at Kingsland. These shops cover an area of over six acres and are equipped for all kinds of car repairs. New shops in course of erection will be equipped for locomotive repairs. A feature of the new work is a truck or platform for transporting cars or locomotives to any part of the shops. This platform is operated on five tracks imbedded in concrete, and laid parallel to and between the old and new shops. Cars can be passed from one building to the other or to the outside at will.

After visiting the painting, upholstering and truck repairing departments, the party made the return trip to New York.

A pleasing feature of the trip was the presence of Mr. Chas. H. Haswell, M. Am. Soc. M. E., perhaps the oldest living Engineer in the world. He will be 98 years of age next May and was about unassisted. Mr. Haswell is still in the engineering field, being on the staff of the Board of Estimate of New York City. His pocketbook for mechanical engineers has been a standard for many years. An excellent photograph of him was obtained in a group picture taken of the party at Hoboken.

The trip was personally conducted by Chief Engineer Bush and members of his staff, Mr. Benj. S. Weaver being in charge of the inspection on behalf of the society.

M. H. L.